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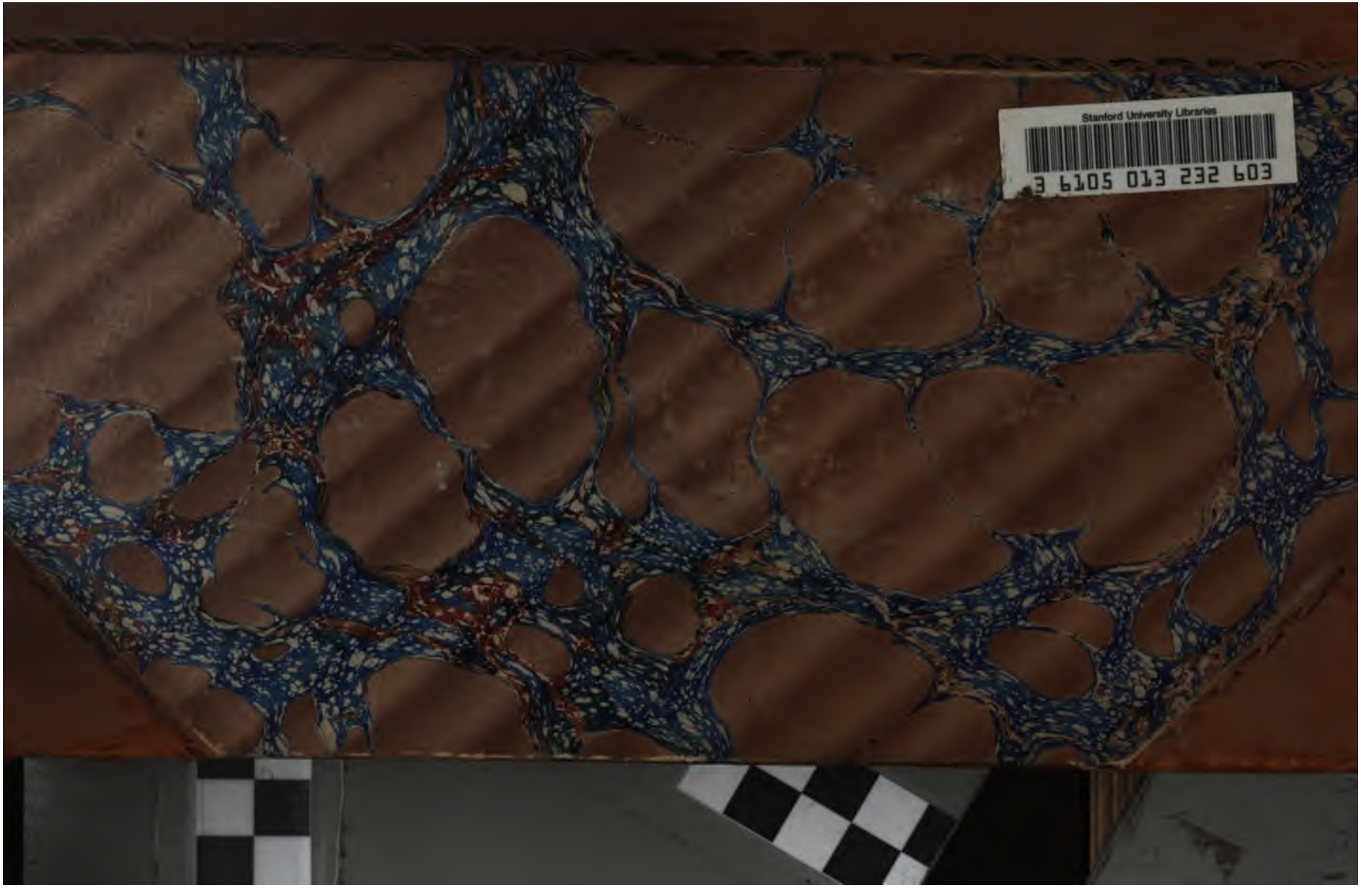
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TRANSACTIONS

OF

THE FEDERATED INSTITUTION

OF

MINING ENGINEERS.

VOL. II.—1890-1891.

EDITED BY M. WALTON BROWN, SECRETARY.

NEWCASTLE-UPON-TYNE: PUBLISHED BY THE INSTITUTION.

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CONTENTS OF VOL. II.

	PAGE.		PAGE.
ADVERTIZEMENT	ii	LIST OF MEMBERS	xvii
CONTENTS	iii	HONORARY MEMBERS	xvii
BYE-LAWS	x	MEMBERS	xviii
OFFICERS	xvi		

GENERAL MEETINGS.

FEDERATED INSTITUTION OF MINING ENGINEERS.

1890.		PAGE.
Sept. 24.	—General Meeting (Nottingham)	21
	"A Geological Sketch of the Town and District of Nottingham." By Mr. George Lewis	22
	Discussion...	27
	"A few Notes on the Ironstone Deposits of Leicestershire." By Mr. M. H. Mills	28
	"An Experience with Explosives used Underground." By Mr. Hargrave Walters	31
	"Elsom's Improved Method of Lighting Miners' Safety-lamps while Locked." By Mr. John Taylor	35
	Discussion...	36
	"The S.C.P. Miners' Electric Safety-lamp." By Mr. G. E. Smith	38
	Discussion...	39
1891.	Excursions	41
Jan. 21.	—General Meeting (Newcastle-upon-Tyne)	145
	"The Steam Loop and Separator." By Prof. J. H. Merivale ...	146
	Discussion...	147
	Discussion on Mr. Albion T. Snell's Paper on "The Distribution of Electrical Energy over Extended Areas in Mines"... ...	149
	Dinner	164
	Conversazione	169
	Excursions	169
May 28.	—General Meeting (London)	249
	Report of Council	249
	Presidential Address	252
	Discussion...	258
	"Locked Coil Wire Ropes." By Mr. William Foggin	261
	Discussion...	266
	"Notes on the Coal-fields of New South Wales." By Mr. George Blake Walker...	268
	"The Coal-fields of Australasia." By Mr. S. Herbert Cox ...	321
	Discussion...	340

89784

1891. FEDERATED INSTITUTION.—*Continued.* PAGE.

"The Economical Use of Steam in Colliery Engines." By Mr. John McLaren 344
Discussion 350
"The Detection of Fire-damp." By Mr. James Ashworth and Prof. F. Clowes 352
Discussion... 357
Dinner 359
May 29.—General Meeting (London) 361
"An Electrical Safety Apparatus for Cages." By Mr. John Yates 362
Discussion... 366
An Investigation as to whether the Fumes produced from the use of Roburite and Tonite in Coal-mines are injurious to health... 368
"Report of the Committee of the Durham Coal Owners' Association and of the Durham Miners' Association" ... 368
"Report on the Chemical Examination of the Fumes." By Dr. P. Phillips Bedson 369
"Report of the Medical Examiners on the Effects produced by the Explosives." By Drs. David Drummond and George H. Hume 385
"Joint Statement of Conclusions and Recommendations." By Drs. P. Phillips Bedson, David Drummond, and George H. Hume 388
Appendices.—"Results of the Chemical Examination of the Fumes from the Explosives, Roburite, Tonite, and Gunpowder." By Dr. P. Phillips Bedson ... 388
"Report of the Engineer on the Experiments with Explosives at Elemore, Haswell, and South Hetton Collieries." By Mr. M. Walton Brown 398
Discussion... 412
"Coal-dust." By Mr. Henry Hall 415
Discussion... 422
The London Hydraulic Power Company 432
The City and South London Railway 434
The General Electric Power and Traction Company, Limited ... 439
The London Electric Supply Corporation, Limited 439
"Notes on the Sinking at the Lens Collieries, No. 10 Pit, by the Poetsch System." By Mr. N. R. Griffith 441
Bristöl Improved Portable Electric Safety-lamp 443
Cuvelier Lock for Safety-lamps 444
Pitkin Portable Batteries and Hand and Miners' Electric Lamps 444
Exhibits of Electric Mining and other Portable Lamps 446

CHESTERFIELD AND MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

1890.
Sept. 24.—General Meeting (Nottingham) 46
1891.
Jan. 10.—General Meeting (Derby) 93
Discussion on Mr. Charles Soar's Paper on "Coal Lowering Arrangements at Granville Colliery (Soar's patent)"... ... 93

CHESTERFIELD AND MIDLAND COUNTIES INSTITUTION.—*Continued.*

		PAGE.
1891.	Discussion on Mr. Albion T. Snell's Paper on "The Distribution of Electrical Energy over Extended Areas in Mines"	94
	Discussion on Mr. E. B. Clarke's Paper on "The Stauss System of Colliery Cage Props"	97
	Discussion on Technical Education	97
	"Germans." By Mr. F. S. Marsh	100
April 11.—	General Meeting (Sheffield)	209
	"On Colliery Depreciation." By Mr. J. Bagnold Smith... ...	211
June 27.—	Annual General Meeting (Nottingham)	503
	Report of the Council...	504
	Accounts...	509
	Representatives on the Council of the Federated Institution of Mining Engineers	511
	Presidential Address	513
	Discussion on Mr. George Lewis' Paper on "A Geological Sketch of the Town and District of Nottingham"	522
	Election of Officers	524
	Discussion on Mr. M. H. Mills' Paper, "A few Notes on the Ironstone Deposits of Leicestershire"	525
	Discussion on Mr. Hargrave Walters' Paper on "An Experience with Explosives used Underground;" Mr. M. Walton Brown's Paper on "Experiments with Explosives used in Mines;" Mr. F. S. Marsh's Paper on "Germans" (Fuzes); and Mr. T. M. W. Wallis' Paper on "The Low Tension System of Shot-firing"...	526
	Discussion on Mr. G. E. Smith's Paper on "The S.C.P. Miners' Electric Safety-lamp"	529
	"The Stanton Ironworks Company's Collieries." By Mr. J. C. B. Hendy	531
	"The Low Tension System of Shot-firing." By Mr. T. M. Winstanley-Wallis	553

MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS.

1890.		
Dec. 16.—	General Meeting (Leeds)	1
	Presidential Address	2
	"On the Coal-field adjoining Barnsley." By Mr. Robert Miller...	7
	Discussion	9
	"On the Parker and Weston Pump for Colliery Purposes." By Mr. G. B. Walker	11
	Discussion on Mr. John Nevin's Paper "On the Difference between the Seams in the Northern and Southern parts of the Yorkshire Coal-field, as shown in some of the Deeper Sinkings"	16
1891.	Papers read before other Federated Institutes	16
Feb. 17.—	General Meeting (Sheffield)	103
	The Federated Institution of Mining Engineers	103

MIDLAND INSTITUTE.—*Continued.*

1891.		PAGE.
	Proposed Joint Meeting and Excursion with the Chesterfield and Midland Counties Institution of Engineers	103
	Discussion on Mr. R. Miller's Paper on "The Coal-field adjoining Barnsley"	105
	Discussion on Mr. Thomas Andrews' Paper on "The Action of Tidal Streams on Metals"	110
	Papers read before other Federated Institutes	111
April 11.	—General Meeting (Sheffield)	112
May 13.	—General Meeting (Barnsley)	447
Aug. 5.	—Annual General Meeting (Barnsley)	448
	The Council's Annual Report...	448
	Accounts...	449
	Representatives on the Council of the Federated Institution of Mining Engineers	452
	Election of Officers	452

MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS, AND CHESTERFIELD AND MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

1891.		
April 11.	—Joint Meeting (Sheffield)	215
	Visit to the Nunnery Colliery (Sheffield)	215
	Discussion upon Mr. Maurice Deacon's Paper on "Comparative Experiments upon a Capell and a Schiele Fan, working under similar conditions"	216
	Discussion upon Mr. G. Blake Walker's Paper "On Coal-getting by Machinery"	230
	Dinner	234
	Description of the Nunnery Colliery, Sheffield	237

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

1890.		
Oct. 11.	—General Meeting (Newcastle-upon-Tyne)	47
	Representatives on the Council of the Federated Institution of Mining Engineers	47
	"Experiments with Explosives used in Mines." By Mr. M. Walton Brown	49
	Discussion...	56
	Discussion on Mr. John Taylor's Paper on "Elsom's Improved Method of Lighting Miners' Safety-lamps while Locked" ...	61

NORTH OF ENGLAND INSTITUTE.—*Continued.*

1890.	PAGE.
Dec. 13.—General Meeting (Newcastle-upon-Tyne)	63
"On the Bending of Beds near Veins." By Mr. David Burns ...	64
Discussion...	67
"Some Banket Deposits of the Gold Coast, West Africa." By Mr. Edward Halse	69
"Experiments with Carbonite." By Messrs. M. Walton Brown and William Foggin	85
Discussion...	87
Electric Mining Safety-lamp	92
1891.	
Feb. 14.—General Meeting (Newcastle-upon-Tyne)	171
"The Waddle Patent (1890) Fan." By Mr. M. Walton Brown...	173
Discussion...	175
April 11.—General Meeting (Newcastle-upon-Tyne)	179
Presidential Address	181
"Notes on the Present Position of the Question of Transmission of Power." By Mr. A. L. Steavenson	191
Discussion...	203
"Memoir of Edward Fenwick Boyd." By his son, Mr. Hugh Fenwick Boyd	204
June 13.—General Meeting (Newcastle-upon-Tyne)	455
Secretary and Treasurer	455
"Pumping Appliances at Eltringham Colliery." By Mr. J. Kenneth Guthrie	457
Discussion...	464
Discussion upon "An Investigation as to whether the Fumes produced from the use of Roburite and Tonite in Coal-mines are injurious to Health"	467
"Fire-damp Detector." By Mr. T. J. Murday	469
Aug. 1.—Annual General Meeting (Newcastle-upon-Tyne)...	470
Awards for Papers	471
Annual Report of the Council	473
Finance Report...	475
Accounts...	476
Discussion...	481
Representatives on the Council of the Federated Institution of Mining Engineers	482
"On a Duplex Arrangement of Centrifugal Ventilating Machines." By Mr. W. Cochrane	483
Discussion...	486
Discussion on Mr. M. Walton Brown's Paper on "Experiments with Explosives used in Mines," and on Messrs. M. Walton Brown and W. Foggin's Paper on "Experiments with Carbonite"	488
Election of Officers	493

SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

1890.		PAGE.
Oct. 2.	—General Meeting (Birmingham)	19
Dec. 11.	—General Meeting (Birmingham)	20
1891.		
March 2.	—Annual General Meeting (Birmingham)	113
	Report of Council	113
	Accounts	115
	Election of Officers	116
	Presidential Address	117
	Steam Loop and Separator	125
	"The Birmingham Central Tramways Company's Electrical Tramway Depôt." By Mr. Henry Lea	127
	"The Birmingham Central Tramways Company's Cable Tramway Depôt." By Mr. Henry Lea	131
	Electric Light Fittings, etc.	134
	Apparatus for Prevention of Overwinding	134
April 2.	—General Meeting (Birmingham)	135
	"Exhibit of Old Mining Implements." By Mr. W. Beattie Scott	135
	"Notes on Colliery Explosions." By Mr. W. Fairley	137
	Discussion	143
	Apparatus for Prevention of Overwinding	144
June 4.	—General Meeting (Birmingham)	241
	Old Mining Implements	241
	Meeting of Federated Institution	241
	Coal-dust Commission	241
	Poetsch System of Sinking Shafts	242
	Discussion on Mr. W. Fairley's "Notes on Colliery Explosions"	242
	"Apparatus for the Prevention of Winding and Overwinding Accidents at Collieries and Blast Furnaces." By Mr. William Grimmitt	243
	Discussion	246
Aug. 6.	—General Meeting	495
	"Barometer and Thermometer as applied to Mining." By Mr. John Williamson	496
	Discussion	500

APPENDICES.

I.—Barometer, Thermometer, etc., Readings, for the Year 1890. By Mr. M. Walton Brown 556

II.—Report of the Corresponding Societies Committee of the British Association, 1890 563

III.—Notes of Papers on the Working of Mines, Metallurgy, etc., from the Transactions of Foreign Societies and Foreign Publications 577

"Coal-mining in Novia Scotia." By Mr. E. Gilpin, Jun. ... 577

"A New Method of Mining Anthracite." By Mr. W. S. Gresley 577

"Coal-measures in the Argentine Republic." By Dr. C. Berg ... 578

"A Gold-field in the Southern Urals." By Mr. R. Helmhacker... 5
"Brine and Natural Gas in Sze-Chuan." By Father Louis Coldre 5
"Report on the Coal Outcrops in the Sharigh Valley, Baluchistan." By Mr. W. King 5
"The Cherra Poonjee Coal-field in the Khasia Hills (India)." By Mr. Tom D. La Touche 5
"The Lakadong Coal-field, Jaintia Hills (India)." By Mr. Tom D. La Touche... 5
"The Coal-fields of Lairungao, Maosandram, and Maobelarkar, in the Khasi Hills (India)." By Mr. Tom D. La Touche... ... 5
"Coal in New Caledonia." By Mr. Porte 5
"The Annina Coal-field in Southern Hungary" 5
"The Fire-damp Explosion at Campagnac." By Mr. Bernard ... 5
"The Explosion at La Machine Colliery (Nièvre)." By Mr. Laurent 5
"The Colliery Explosion at Polnisch-Ostrau." By Mr. Joh. Meyer 5
"The Berlin (1889) Mining Exhibition." By Mr. Maurice Bellom 5
"Determination of the Flashing Point of Fire-damp." By Mr. H. Le Chatelier 5
"Report of French Commission on the Inflammability of Fire-damp by Sparks produced by Steel Tools, and on the Employment of Electric Lamps." By Messrs. Mallard, Le Chatelier, and Chesneau 5
"Experiments in Sedimentation." By Prof. J. Thoulet 5

INDEX 51

FEDERATED INSTITUTION OF MINING ENGINEERS.

Bye-Laws passed at Council Meeting held on May 28th, 1891.

I.—CONSTITUTION.

1.—The Federated Institution of Mining Engineers shall consist of all or any of the societies interested in the advancement of mining, metallurgy, engineering, and their allied industries, who shall from time to time join together and adhere to the Bye-Laws.

2.—The Institution shall have for its objects—

(*a*) The advancement and encouragement of the sciences of mining, metallurgy, engineering, and their allied industries.

(*b*) The interchange of opinions, by the reading of communications from members and others, and by discussions at general meetings, upon improvements in mining, metallurgy, engineering, and their allied industries.

(*c*) The publication of original communications, discussions, and other papers connected with the objects of the Institution.

(*d*) The purchase and disposal of real and personal property for such objects.

(*e*) The performance of all things connected with or leading to the purpose of such objects.

3.—The offices of the Institution shall be in Newcastle-upon-Tyne, or such other place as shall be from time to time determined by resolution of the Council.

4.—The year of the Institution shall end on July 31st in every year.

5.—The affairs and business of the Institution shall be managed and controlled by the Council.

II.—MEMBERSHIP.

6.—The original adherents or founders are as follows:—

(*a*) Chesterfield and Midland Counties Institution of Engineers, Chesterfield.

(*b*) Midland Institute of Mining, Civil, and Mechanical Engineers, Barnsley.

(*c*) North of England Institute of Mining and Mechanical Engineers, Newcastle-upon-Tyne.

(*d*) South Staffordshire and East Worcestershire Institute of Mining Engineers, Birmingham.

7.—Written applications from societies to enter the Institution shall be made to the Council, by the President of the applying society, who shall furnish any information that may be desired by the Council.

8.—A.—If desired by the Council, any of the Federated Institutes shall revise their Bye-Laws, in order that their members shall consist of Ordinary Members, Associate Members, and Honorary Members, with Associates and Students, and section B following shall be a model Bye-Law to be adopted by any society when so desired by the Council.

B.—"The members shall consist of Ordinary Members, Associate Members, and Honorary Members, with Associates and Students:—

(*a*) Each Ordinary Member shall be more than twenty-three years of age, have been regularly educated as a mining, metallurgical, or mechanical engineer, or in some other branch of engineering, according to the usual routine of pupilage, and have had subsequent employment for at least two years in some responsible situation as an engineer; or if he has not undergone the usual routine of pupilage, he must have been employed or have practised as an engineer for at least five years.

(*b*) Each Associate Member shall be a person connected with or interested in mining, metallurgy, or engineering, and not practising as a mining, metallurgical, or mechanical engineer, or some other branch of engineering.

(*c*) Each Honorary Member shall be a person who has distinguished himself by his literary or scientific attainments, or who may have made important communications to any of the Federated Institutes.

(*d*) Associates shall be persons acting as under-viewers, under-managers, or in other subordinate positions in mines or metallurgical works, or employed in analogous positions in other branches of engineering.

(*e*) Students shall be persons who are qualifying themselves for the profession of mining, metallurgical, or mechanical engineering, or other branch of engineering, and such persons may continue Students until they attain the age of twenty-five years."

9.—The Ordinary Members, Associate Members, and Honorary Members, Associates and Students shall have notice of, and the privilege of attending, the ordinary and annual general meetings, and shall receive all publications of the Institution. They may also have access to, and take part in, the general meetings of any of the Federated Institutes.

10.—The members of any Federated Institute, whose payments to the Institution are in arrear, shall not receive the publications and other privileges of the Institution.

11.—After explanations have been asked by the President from any Federated Institute, whose payments are in arrear, and have not been paid within one month after written application by the Secretary, the Council may decide upon its suspension or expulsion from the Institution; but such suspension or expulsion shall only be decided at a meeting attended by at least two-thirds of the members of the Council by a majority of three-fourths of the members present.

III.—Subscriptions.

12.—Each of the Federated Institutes shall pay fifteen shillings per annum for each Ordinary Member, Associate Member, Honorary Member, Associate, and Student, or such other sum, and in such instalment or instalments as may be determined from time to time by resolution or resolutions of the Council. Persons joining any of the Federated Institutes during the financial year of the Federated Institution shall be entitled to all publications issued for that year, after his election is notified to the Secretary, and the instalment or instalments due on his behalf have been paid.

IV.—Election of Officers and Council.

13.—The officers of the Institution, other than the Secretary and Treasurer, shall consist of Councillors elected annually prior to August in each year, by and out of the Ordinary Members and Associate Members of each Federated Institute, in the proportion of one Councillor per forty Ordinary Members or Associate

Members thereof; of Vice-Presidents elected by and from the Council at their first meeting in each year on behalf of each Institute, in the proportion of one Vice-President per two hundred Ordinary Members or Associate Members thereof; and of a President elected by and from the Council at their first meeting in each year; who, with the Local Secretaries of each Federated Institute and the Secretary and Treasurer shall form the Council. All Presidents on retiring from that office shall be *ex-officio* Vice-Presidents so long as they continue Ordinary Members or Associate Members of any of the Federated Institutes.

14.—In case of the decease, expulsion, or resignation of any officer or officers, the Council may, if they deem it requisite, fill up the vacant office or offices at their next meeting.

V.—Duties of Officers and Council.

15.—The Council shall represent the Institution and shall act in its name, and shall make such calls upon the Federated Institutes as they may deem necessary, and shall transact all business and examine accounts, authorise payments and may invest or use the funds in such manner as they may from time to time think fit, in accordance with the objects and Bye-Laws of the Institution.

16.—The Council shall decide the question of the admission of any society, and may decree the suspension or expulsion of any Federated Institute for non-payment of subscriptions.

17.—The Council shall decide upon the publication of any communications.

18.—There shall be three ordinary meetings of the Council in each year, on the same day as, but prior to, the ordinary or annual general meetings of the members.

19.—A special meeting of the Council shall be called whenever the President may think fit, or upon a requisition to the Secretary signed by ten or more of its members, or by the President of any of the Federated Institutes. The business transacted at a special meeting of the Council shall be confined to that specified in the notice convening it.

20.—The meetings of the Council shall be called by circular letter, issued to all the members at least seven days previously, accompanied by an agenda paper, stating the nature of the business to be transacted.

21.—The order in which business shall be taken at the ordinary and annual general meetings may be, from time to time, decided by the Council.

22.—The Council may communicate with the Government in cases of contemplated or existing legislation, of a character affecting the interests of mining, metallurgy, engineering, or their allied industries.

23.—The Council may appoint Committees, consisting of members of the Institution, for the purpose of transacting any particular business, or of investigating any specific subject connected with the objects of the Institution.

24.—A Committee shall not have power or control over the funds of the Institution, beyond the amount voted for its use by the Council.

25.—Committees shall report to the Council, who shall act thereon and make use thereof as they may elect.

26.—The President shall take the chair at all meetings of the Institution, the Council, and Committees at which he may be present.

27.—In the absence of the President, it shall be the duty of the senior Vice-President present to preside at the meetings of the Institution. In case of the absence of the President and of all the Vice-Presidents, the meeting may elect any member of Council, or in case of their absence any Ordinary Member or Associate Member to take the chair at the meeting.

28.—At meetings of the Council six shall be a quorum.

29.—Every question shall be decided at the meetings of the Council by the votes of the majority of the members present. In case of equal voting, the President, or other member presiding in his absence, shall have a casting vote. Upon the request of two members, the vote upon any question shall be by ballot.

30.—The Secretary shall be appointed by and shall act under the direction and control of the Council. The duties and salary of the Secretary shall be fixed and varied from time to time at the will of the Council.

31.—The Secretary shall summon and attend all meetings of the Council, and the ordinary and annual general meetings of the Institution, and shall record the proceedings in the minute book. He shall direct the administrative and scientific publications of the Institution. He shall have charge of and conduct all correspondence relative to the business and proceedings of the Institution, and of all committees where necessary, and shall prepare and issue all circulars to the members.

32.—One and the same person may hold the office of Secretary and Treasurer.

33.—The Treasurer shall be appointed annually by the Council at their first meeting in each year. The income of the Institution shall be received by him, and shall be paid into Messrs. Lambton & Co.'s bank at Newcastle-upon-Tyne, or such other bank as may be determined from time to time by the Council.

34.—The Treasurer shall make all payments on behalf of the Institution, by cheques signed by two members of Council, the Treasurer, and the Secretary, after payments have been sanctioned by Council.

35.—The surplus funds may, after resolution of the Council, be invested in Government securities, in railway and other debenture shares such as are allowed for investment by trustees, in the purchase of land, or in the purchase, erection, alteration, or furnishing of buildings for the use of the Institution. All investments shall be made in the names of Trustees appointed by the Council.

36.—The accounts of the Treasurer and the financial statement of the Council shall be audited and examined by a chartered accountant, appointed by the Council at their first meeting in each year. The accountants' charges shall be paid out of the funds of the Institution.

37.—The minutes of the Council's proceedings shall at all times be open to the inpection of the Ordinary Members and Associate Members.

VI.—General Meetings.

38.—An ordinary general meeting shall be held in February, May, and September, unless otherwise determined by the Council; and the ordinary general meeting in the month of September shall be the annual general meeting at which a report of the proceedings, and an abstract of the accounts of the previous year ending July 31st, shall be presented by the Council. The ordinary general meeting in the month of May shall be held in London, at which the President may deliver an address.

39.—Invitations may be sent by the Secretary to any person whose presence at discussions shall be thought desirable by the Council, and persons so invited shall be permitted to read papers and take part in the proceedings and discussions.

40.—Discussion may be invited on any paper published by the Institution, at meetings of any of the Federated Institutes, at which the writer of the paper may be invited to attend. Such discussion, however, shall in all cases be submitted to the writer of the paper before publication, and he may append a reply at the end of the discussion.

VII.—PUBLICATIONS.

41.—The publications may comprise:—

(*a*) Papers upon the working of mines, metallurgy, engineering, railways and the various allied industries.

(*b*) Papers on the management of industrial operations.

(*c*) Abstracts of foreign papers upon similar subjects.

(*d*) An abstract of the patents relating to mining and metallurgy, etc.

(*e*) Notes of questions of law concerning mines, manufactures, railways, etc.

42.—Each paper (with complete drawings, if any, to scale), to be read at any meeting of the Institution or of any of the Federated Institutes shall be placed in the hands of the Secretary at least fourteen days before the date of the meeting at which the paper is to be read, and shall, subject to the approval of the Council, be printed, together with any discussion or remarks thereon.

43.—The Council may accept communications from persons who are not members of the Institution and allow them to be read at the ordinary or annual general meetings.

44.—No paper which has already been published (except as provided for in Bye-Law 41) shall appear in the publications of the Institution.

45.—A paper in course of publication cannot be withdrawn by the writer.

46.—Proofs of all papers and reports of discussions forwarded to any person for revision must be returned to the Secretary within seven days from the date of their receipt, otherwise they will be considered correct and be printed off.

47.—The copyright of all papers accepted for printing by the Council shall become vested in the Institution, and such communications shall not be published for sale or otherwise without the written permission of the Council.

48.—Twenty copies of each paper and the accompanying discussion shall be presented to the writer free of cost. He may also obtain additional copies upon payment of the cost to the Secretary, by an application attached to his paper. These copies must be unaltered copies of the paper as appearing in the publication of the Institution, and the cover shall state that it is an "Excerpt from the Transactions of the Federated Institution of Mining Engineers."

49.—The Federated Institutes may receive copies of their own portion of the publications in respect of such of their members as do not become members of the Federated Institution, and shall pay 10s. per annum in respect of every copy so supplied; and similar copies for exchanges shall be paid for at cost price.

50.—The Local Secretary of each Federated Institute shall prepare and edit all papers and discussions of such Institute, and promptly forward them to the Secretary, who shall submit proofs to the Local Secretary before publication.

51.—A list of the members, with their last known addresses, shall be printed in the publications of the Institution.

52.—The publications of the Institution shall only be supplied to members, and no duplicate copies of any portion of the publications shall be issued to any member or Federated Institute unless by order of the Council.

53.—The annual volume or volumes of the publications may be sold, in the complete form only, at such prices as may be determined from time to time by the Council; to non-members for not less than £3; and to members who are desirous of completing their sets of the publications, for not less than 15s.

54.—The Institution as a body is not responsible for the statements and opinions advanced in the papers which may be read or in the discussions which may take place at the meetings of the Institution, or of the Federated Institutes.

VIII.—Medals and other Rewards.

55.—The Council may award annually the sum of twenty pounds, in the form of medals or other rewards, to the authors of papers published by the Institution.

IX.—Property.

56.—The capital fund shall consist of such amounts as shall from time to time be determined by resolution of the Council.

57.—The Institution may make use of the following receipts for its expenses :—

(*a*) The interest of its accumulated capital fund;

(*b*) The annual subscriptions; and

(*c*) Receipts of all other descriptions.

58.—The Institution may form a collection of papers, books, and models.

59.—Societies or members who may have ceased their connexion with the Institution shall have no claim to participate in any of its properties.

60.—All donations to the Institution shall be acknowledged in the annual report of the Council

X.—Alteration of Bye-Laws.

61.—No alteration shall be made in the Bye-Laws of the Institution, except at a special meeting of the Council called for that purpose, and the particulars of every such alteration shall be announced at their previous meeting, and inserted in the minutes, and shall be sent to all members of Council at least fourteen days previous to such special meeting, and such special meeting shall have power to adopt any modification of such proposed alteration of the Bye-Laws, subject to confirmation by the next ensuing Council meeting.

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J. M. RONALDSON, ESQ., H.M. Inspector of Mines, 44, Athole Gardens, Glasgow.
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ALLAN, GEORGE, Corngreaves Hall, Birmingham.
ALLAN, JOHN F., c/o Messrs. Caldwell and Watson, 109, Fenchurch Street, London, E.C.
ALLEN, REUBEN, Albert Colliery, Newbold, Chesterfield.
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ALSOP, A. B., Pinxton Collieries, Alfreton.
ALSOP, SAMUEL, Pool Close, Pinxton, Alfreton.
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ANDREWS, GEORGE MURRAY, B.A., Broomhill Colliery, Northumberland.
ANDREWS, HUGH, Swarland Hall, Felton, Northumberland.
ANDREWS, THOMAS, Wortley Iron Works, near Sheffield.
ARCHER, JOSEPH, Queen Insurance Buildings, Church Street, Sheffield.
ARCHER, T., 6, Park Terrace, Gateshead-upon-Tyne.
ARMSON, JESSE, Swannington Colliery, near Ashby-de-la-Zouch.
ARMSTRONG, LORD, C.B., LL.D., D.C.L., Cragside, Rothbury.
ARMSTRONG, HY., Pelaw House, Chester-le-Street.
ARMSTRONG, J. H., St. Nicholas' Chambers, Newcastle-upon-Tyne.
ARMSTRONG, T. J., Hawthorn Terrace, Newcastle-upon-Tyne.
ARMSTRONG, WM., Pelaw House, Chester-le-Street.
ARMSTRONG, W., Jun., Wingate, Co. Durham.
ARMSTRONG, W. L., Newton Lane Colliery, Victoria Coal and Coke Co., Limited, near Wakefield.
ARNOLD, T., Mineral Surveyor, Castle Hill, Greenfields, Llanelly.
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ASTON, J., Blowers Green, Dudley, Worcestershire.
ATKINSON, A. A., Barrow Collieries, Barnsley, Yorkshire.
ATKINSON, FRED. R., Winton Square, Stoke-upon-Trent.
ATKINSON, J. W., Chantry Road, Norton Woodseats, Sheffield.

AUBREY, R. C., 14, St. Paul's Square, Southport.
AUDUS, T., Mineral Traffic Manager, North Eastern Railway, Newcastle-upon-Tyne.
AUSTINE, JOHN, Cadzow Coal Co., Glasgow.
AYTON, HENRY, Cowpen Colliery, Blyth, Northumberland.

BAILES, E. T., Wingate, Ferryhill.
BAILES, T., Jesmond Gardens, Newcastle-upon-Tyne.
BAILEY, E. J., 30, Waterloo Street, Birmingham.
BAILEY, SAMUEL, 30, Waterloo Street, Birmingham.
BAIN, R. DONALD, H.M. Inspector of Mines, 85, Pembroke Road, Clifton, Bristol.
BAINBRIDGE, EMERSON, Nunnery Colliery Offices, Sheffield.
BAKER, GODFREY, Cromford Road, Ripley, Derby.
BALFOUR, J. L., Jun., Millfield, Tamworth.
BALL, ALFRED F., 14, Landsdowne Terrace, Gosforth.
BALL, JOSIAH, Teversal Collieries, Mansfield.
BANCROFT, ROBERT E., Daisyfield, Alderley Edge, near Manchester.
BANKS, THOMAS, 60, King Street, Manchester.
BARBER, THOMAS, Lamb Close House, Eastwood, Notts.
BARNES, ALFRED, M.P., Ashgate Lodge, Chesterfield.
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BARROW, J. B., Ringwood Hall, near Chesterfield.
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BATTY, W., Darley Grove, Worsbro' Dale, Barnsley.
BAUMGARTNER, W. O., Houghton-le-Spring, Fence Houses.
BAYLDON, DANIEL HY., 3, Drapers' Gardens, London, E.C.
BAYLEY, THOMAS, The Park, Nottingham.
BEANLANDS, ARTHUR, M.A., Palace Green, Durham.
BELK, WILLIAM JAMES, Thorncliffe Collieries, near Sheffield.
BELL, GEO. FRED., H.M. Inspector of Mines, 4, St. Thomas' Square, Newcastle-upon-Tyne.
BELL, J., Wardley Colliery, Newcastle-upon-Tyne.
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BENSON, J. G., 12, Grey Street, Newcastle-upon-Tyne.
BENSON, T. W., 11, Newgate Street, Newcastle-upon-Tyne.
BENTON, Prof. W. E., 63, Pitt Street, Sydney, New South Wales.
BERKLEY, C., Marley Hill, Whickham, R.S.O., Co. Durham.
BERKLEY, FREDERICK, Lumley Thicks, Fence Houses.
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BEWICK, T. B., Suffolk House, Laurence Pountney Hill, London, E C.
BEWICK, T. J., Suffolk House, Laurence Pountney Hill, London, E.C.

BIGGE, D. SELBY, 27, Mosley Street, Newcastle-upon-Tyne
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BLACK, W., Hedworth Villa, South Shields.
BLACKBURN, W. STEVENSON, Astley House, Woodlesford, near Leeds.
BLACKETT, W. C., Jun., Acorn Close, Sacriston, Durham.
BLAGBURN, CHARLES, 150, Leadenhall Street, London, E.C.
BLAKELEY, A. B., Soothill Wood Colliery, Batley.
BLAKEMORE, W., Jr., Shelfield, near Walsall.
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*BOOTH, R. L., Ashington Colliery, near Morpeth.
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BOWEN, J., Broad Street, Bilston.
*BOYD, R. F., Houghton-le-Spring, Fence Houses, Co. Durham.
BOYD, WM., North House, Longbenton, Newcastle-upon-Tyne.
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BRAMWELL, HUGH, Clifton Colliery, Great Clifton, near Workington.
BRECKON, J. R., 41, Fawcett Street, Sunderland.
BREWIS, GEORGE, Boythorpe Colliery, Chesterfield.
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BRIDGEWATER TRUSTEES, c/o Clifford Smith, Esq., Bridgewater Offices, Walkden, Bolton-le-Moors, Lancashire.
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BROUGH, BENNETT H., 5, Robert Street, Adelphi, London, W.C.
BROUGH, THOMAS, New Seaham Colliery, Sunderland.
BROUGHALL, J., The Hollies, Essington.
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BROWN, THOS. FORSTER, Guildhall Chambers, Cardiff.
BROWN, WESTGARTH F., Alston House, Cardiff.
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BUNNING, C. Z., c/o The Borax Co., Limited, 2, Macri Khan, Constantinople.
BURDON, A. E., Hartford House, Cramlington, Northumberland.
BURLS, HERBERT T., Box 76, Barberton, Transvaal, South Africa.
BURN, F. H., Beaconsfield, Cullercoats.
BURN, JAMES, 28, Fawcett Street, Sunderland.
BURNLEY, G. J., Birthwaite Hall, Darton, Barnsley.
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CHALMERS, GEORGE, Superintendent of the St. John del Rey Mining Co., 28, Tower Chambers, Finsbury Pavement, London, E.C.
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CLARKE, JAMES A., Ayr Colliery, Annbank, N.B.
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CLAY, S. E., Venezuelan Austin Gold Mining Co., Limited, Dashwood House' 9, New Broad Street, London, E.C.
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CLOUGH, JAMES, Willow Bridge, Choppington, Morpeth.
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COCHRANE, NAPIER, Aldin Grange, Durham.
COCHRANE, R. D., Hetton Colliery Offices, Fence Houses.
COCHRANE, W., St. John's Chambers, Grainger Street West, Newcastle-upon-Tyne.
COCKBURN, W. C., 1, St. Nicholas' Buildings, Newcastle-upon-Tyne.
COCKIN, T. H., Tinsley Park Colliery, Sheffield.
COCKSON, CHARLES, Ince Coal and Cannel Co., Ince, Wigan.
COKE, G. E., 65, Station Street, Nottingham.
COLDICUTT, HERBERT, Highfields Farm, Quinton, Birmingham.
COLE, C. E., Pensnett, Dudley, Worcestershire.
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COTTERELL, O. J., 16, Bank Street, Sheffield.
COULSON, F., 10, Victoria Terrace, Durham
COULSON, W., No. 1, Pimlico, Durham.
COULTHARD, FRANCIS, Minas del Penoncello, Marbello, Provincia de Malago, Spain.
COX, J. H., 10, St. George's Square, Sunderland.
COX, L. C., Ravenstone, Ashby-de-la-Zouch.
COXE, E. B., Drifton, Jeddo, P.O. Luzerne Co., Penns., U.S.A.
CRADOCK, G., Rope Works, Wakefield
CRAIK, T., Church Street, Barnsley.
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CRAVEN, JOHN, Westgate Common, Wakefield.
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CRAWSHAY, G., West House, Tynemouth.

CRESWICK, A. J., Gatefield, Sheffield.
CRESWICK, W., Sharlestone Colliery, Normanton.
CRIGHTON, JOHN, Albert Villa, Victoria Park, Manchester.
CROMPTON, GEORGE, Stanton Hall, Nottingham.
CRONE, E. W., Forest Hall, near Newcastle-upon-Tyne.
CRONE, F. E.
CRONE, J. R., Tudhoe House, *via* Spennymoor.
CRONE, S. C., Forest Hall, Newcastle-upon-Tyne.
CROOKES, ARTHUR, The Mount, Eckington, Rotherham.
CROSS, JOHN, 77, King Street, Manchester.
CROSS, W. ASSHETON, Messrs. R. and W. Hawthorn, Newcastle-upon-Tyne.
CROUDACE, C. J., Bettisfield Colliery Co., Limited, Bagillt, North Wales.
CROUDACE, JOHN, West House, Haltwhistle.
CROUDACE, THOMAS, Lambton Lodge, Lambton, Newcastle, New South Wales.
CURRY, W. THOS., Ulverston, Lancashire.

DACRES, THOMAS, Dearham Colliery, *via* Carlisle.
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DALE, DAVID, West Lodge, Darlington.
*D'ANDRIMONT, T., Liège, Belgium.
DARLING, FENWICK, South Durham Colliery, Darlington.
DARLINGTON, JAMES, Black Park Colliery, Ruabon, North Wales.
DAVEY, HENRY, 3, Princes Street, Westminster, London, S.W.
DAVIES, Lt.-Col. JASPER G. S., R.E., Marton, Middlesbrough.
DAVIES, JOHN, Hartley House, Coundon, Bishop Auckland.
DAVIES, T. J., Balls Hill, West Bromwich.
DAVIES, WATKIN, Sheepbridge Iron Works, Chesterfield.
DAVIES, W. J., Bradley, Bilston.
DAVIS, HENRY, All Saints Works, Derby.
DAVIS, KENNETH MCRAE, Dudley Colliery, Northumberland.
DAVY, GEORGE, Eckington Collieries, Rotherham.
DAWBARN, A. G., 60, Gracechurch Street, London, E.C.
DAY, J. H., The Laurels, Bull Bridge, Ambergate, Derby.
DEACON, MAURICE, Blackwell Collieries, Alfreton.
DEES, J. GIBSON, Floraville, Whitehaven.
DEES, R. R., Solicitor, Newcastle-upon-Tyne.
DENNIS, HENRY, Ruabon.
DENNISTON, ROBERT B., Stuart Street, Dunedin, New Zealand.
DEVONSHIRE, THE DUKE OF, K.G., Chatsworth, Chesterfield.
DIAMOND, JAMES, Pye Bridge, Alfreton.
DICKENSON, CHARLES, North West Coal Syndicate, Limited, Canmore, Alberta, Canada.
DICKINSON, GEORGE W., Clay Cross, Chesterfield.
DIXON, D. W., Lumpsey Mines, Brotton, Saltburn-by-the-Sea.
DIXON, JAMES S., 97, Bath Street, Glasgow.
DIXON, R., 10, Claremont Terrace, Newcastle-upon-Tyne.
DOBINSON, LANCELOT, Victoria Coal Company, Park Hills Colliery, Wakefield.
DODD, B., Bearpark Colliery, near Durham.
DODD, M., Burncroft, Hexham.
DONKIN, W., Warora Colliery, Wardha Coal State Railway, C. P., India.

DOUGLAS, A. S., Hucknall Torkard Colliery, Nottingham.
DOUGLAS, C. P., Parliament Street, Consett, Co. Durham.
DOUGLAS, JOHN, Jun., Seghill Colliery, Dudley, Northumberland.
DOUGLAS, M. H., Usworth Colliery, Washington, R.S.O., Co. Durham.
DOUGLAS, T., The Garth, Darlington.
DOWDESWELL, H., Butterknowle Colliery, *via* Darlington.
DOYLE, PATRICK, Indian Engineering, 19, Lall Bazar, Calcutta, India.
DRAPER, W., New Seaham Colliery, Sunderland.
DUNN, GEO., Netherton. Worcestershire.
DURHAM, EARL OF, Lambton Offices, Fence Houses.
DURNFORD, H. S., Wharncliffe Silkstone Colliery, Barnsley.
DUTSON, JOHN, Orgreave Colliery, near Sheffield.
*DYSON, GEORGE, Middlesbrough.
DYSON, W. H., Eckington Collieries, Rotherham.

EAMES, W., Netherseal Colliery, Burton-on-Trent.
EARDLEY, EDWIN, 7, Wilson Street, Derby.
EARDLEY, J. W., The Old Vicarage, Alfreton.
EASTWOOD, EDWARD, Railway Wagon Works, Chesterfield.
EASTWOOD, G. A., Tapton Villa, Chesterfield.
EATON, JOHN, Cliff House, Clowne, Chesterfield.
EDEN, C. H., c/o Messrs. Vivian and Sons, Swansea.
EDGE, J. H., Coalport Wire Rope and Chain Works, Shifnal, Salop.
EDWARDS, F. H., Forth House, Bewick Street, Newcastle-upon-Tyne.
ELCE, GEORGE, Clayton-le-Moors, Accrington, Lancashire.
ELEY, J. J., Snydale Collieries, near Pontefract.
ELLIOT, Sir GEORGE, Bart., D.C.L., 1, Park Street, Park Lane, London, W.
ELLIS, W. R., Wigan.
ELSDON, ROBERT, The Highlands, Burnt Ash Hill, Lee, Kent.
ELWEN, THOMAS LEE, Littleburn Colliery, near Durham.
EMBLETON, T. W., The Cedars, Methley, Leeds.
EMBLETON, T. W., Jun., The Cedars, Methley, Leeds.
EMINSON, J. B., Londonderry Offices, Seaham Harbour.
ERSKINE, Capt., W. C. C., Inspector of Mines, Kimberley, South Africa.
EVERARD, J. B., 6, Millstone Lane, Leicester.

FAIRLEY, JAMES, Craghead and Holmside Collieries, Chester-le-Street.
FAIRLEY, W., Beau Desert, Rugeley.
FARMER, A., Seaton Carew, near West Hartlepool.
FARNWORTH, W., Swindon, Dudley, Worcestershire.
FARRAR, JAMES, Old Foundry, Barnsley.
FARROW, JOSEPH, Brotton Mines, Brotton, R.S.O.
FEARN, J. W., Devonshire Street, Chesterfield.
FELLOWS, J. M., Pensnett, near Dudley. Worcestershire.
FENWICK, BARNABAS, 84, Osborne Road, Newcastle-upon-Tyne.
FENWICK. P. J., New Hucknall Colliery, near Mansfield.
FENWICK, T. E., Mayfield, Wolsingham, near Darlington.
FERENS, FREDERICK J., Silksworth Colliery, Sunderland.
*FERENS, ROBINSON, Oswald Hall, near Durham.

FERGUSON, D., The Persian Bank Mining Rights Corporation, Limited, 6, Drapers Gardens, London, E.C.
FIELD, J., Hill Top, West Bromwich.
FINCKEN, C. W., Hoyland Silkstone Colliery, Barnsley.
FIRTH, J., Hunslet New Road, Leeds.
FIRTH, W., Water Lane, Leeds.
FISHER, ED. R., Nant Glas, Cross Hands, near Llanelly, South Wales.
FISHER, HENRY, Clifton Colliery, Nottingham.
FISHER, T., Walsall.
FITTON, GEORGE, Wortley, near Leeds.
FLEMING, C. E., Black, Hawthorn, and Co., Gateshead-upon-Tyne.
FLETCHER, HERBERT, The Hollins, Bolton.
FLETCHER, JOHN, Gill House, Ulverstone.
FLETCHER, LANCELOT, Brigham Hill, Carlisle.
FLETCHER, W., Brigham Hill, *via* Carlisle.
FOGGIN, W., North Biddick Colliery, Washington Station, Co. Durham.
FORD, ISAAC, Rotherham Main Colliery, Rotherham.
FORREST, B. J., Villa Maria, Province of Cordoba, Argentine Republic.
FORREST, J. C., Holly Bank Colliery, Essington, Wolverhampton.
FORSTER, C. W., 6, North Jesmond, Newcastle-upon-Tyne.
FORSTER, G. B., M.A., North Jesmond, Newcastle-upon-Tyne.
FORSTER, J. R., Water Company's Office, Newcastle-upon-Tyne.
FORSTER, J. T., Burnhope Colliery, near Lanchester, Co. Durham.
FORSTER, J. W., 24, Silksworth Terrace, New Silksworth, Sunderland.
FORSTER, T. E., North Jesmond, Newcastle-upon-Tyne.
FOSTER, GEORGE, Osmondthorpe Colliery, Leeds.
FOWLER, GEORGE, Basford Hall, Nottingham.
FOWLER, W. C., Beeston, Notts.
FRYAR, J. W., Seghill Colliery, Seghill, Northumberland.
FRYAR, MARK, Denby Colliery, Derby.

GALLOWAY, T. LINDSAY, M.A., Argyll Colliery, Campbeltown, N.B.
GALLOWAY, W., Cardiff.
GALLWEY, A. P., Box 138, Post Office, Johannesburg, S.A.R.
GARFORTH, W. E., West Riding Colliery, Normanton.
GASCOYNE, ROWLAND, Brappan Colliery, Boxburg, Johannesburg, S.A.R.
GEDDES, GEORGE H., 142, Princes Street, Edinburgh.
GERRARD, JAMES, 11, Meek's Buildings, Wigan.
GERRARD, JOHN, H.M. Inspector of Mines, Worsley, Manchester.
GIBBONS, J. L., Ellowes Hall, Ruiton, Dudley, Worcestershire.
GIBBS, HUBERT, Rookery Road, Handsworth, Birmingham.
GILCHRIST, J. R., Garesfield Colliery, Lintz Green, Newcastle-upon-Tyne.
GILL, THOMAS, Trowell Moor Colliery, near Nottingham.
GILLETT, L. F., 163, Osmaston Road, Derby.
GILLOT, J. W., Summer Lane, Barnsley.
GILROY, G., Orrel, Wigan.
GILROY, S. B., Nuneaton.
GJERS, JOHN, 3, Southfield Villas, Middlesbrough.
GLENNIE, W. H., 10, Oxford Road, Erdington, Birmingham.
*GODDARD, F. R., Accountant, Newcastle-upon-Tyne

GRAINGER, JAMES, Woollaton, Nottingham.
GRATTON, R. T., Knifesmith Gate, Chesterfield.
GRAVES, H. G., 5, Robert Street, Adelphi, London.
GRAZEBROOK, A. W., Queen Cross, Dudley, Worcestershire.
GREAVES, J. O., St. John's, Wakefield.
GREEN, J. T., Ty Celyn, Abercarne, Newport, Mon.
GREENER, HENRY, South Pontop Colliery, Annfield Plain.
GREENER, JOHN, General Manager, Vale Colliery, New Glasgow, Pictou, Nova Scotia.
GREENER, T. Y., West Lodge, Crook, Darlington.
GREENSMITH, JOHNSON, Newstead Colliery, Nottingham.
GREENWELL, G. C., Elm Tree Lodge, Duffield, Derby.
GREENWELL, G. C., Jun. Poynton, near Stockport.
GREENWOOD, Prof. W. H., 21, Portland Road, Edgbaston, Birmingham.
GRESLEY, W. S., Reed House, Erie, Pa., U.S.A.
GREY, C. G., 20, Northbrook Road, Leeson Park, Dublin.
GRIFFITH, ED., Brymbo Colliery, Wrexham, North Wales.
GRIFFITH, N. R., Wrexham.
GRIFFITHS, F., Pensnett, near Dudley.
GRIMSHAW, E. J., 23, Hardshaw Street, St. Helen's, Lancashire.
GUTHRIE, JAMES K., Eltringham Colliery, Prudhoe, R.S.O.
GUTHRIE, REGINALD, Neville Hall, Newcastle-upon-Tyne.
GUY, JOHN GEORGE, 8, South Terrace, Job's Hill, Crook, R.S.O., Co. Durham.

HABERSHON, M. H., Thorncliffe Colliery, near Sheffield.
HADDOCK, W. T., Jun., The Durban-Roodeport Gold Mining Company, Limited, Roodeport, near Johannesburg, Z.A.R.
HADFIELD, R. A., Hecla Steel Foundry, Sheffield.
HAGGIE, D. H., Wearmouth Patent Rope Works, Sunderland.
HAGGIE, F. W., Gateshead-upon-Tyne.
HAGGIE, G. A., Wearmouth Ropery, Sunderland.
HAGGIE, PETER SINCLAIR, Gateshead-upon-Tyne.
HAGUE, ERNEST, Castle Dyke, Sheffield.
HAGUE, W. B., Alma Collieries, Clay Cross, Chesterfield.
HAINES, J. RICHARD, Adderley Green Colliery, near Longton, Stoke-on-Trent.
HALL, EDGAR, Wharncliffe Silkstone Colliery, Barnsley.
HALL, FRED. W., Haswell Lodge, Sunderland.
HALL, GEORGE, Bengal Iron and Steel Company, Barrakur, Bengal, India.
HALL, JOHN, Sheepbridge Works, Chesterfield.
HALL, J. C., Pegswood Colliery, near Morpeth.
HALL, L. J., Furness Vale, Stockport.
HALL, M., Lofthouse Station Collieries, near Wakefield.
HALL, M. S., 8, Victoria Street, Bishop Auckland.
HALL, TOM, Ryhope Colliery, near Sunderland.
HALL, WM.
HALL, W. F., Haswell Colliery, Haswell, *via* Sunderland.
HALLAS, G. H., Wigan and Whiston Coal Co., Limited, Prescot.
HALLIMOND, W. TASKER, Estate Manager, Randt Coal Mining and Land Co., Limited, P.O. Box 506, Johannesburg, Z.A.R.
HALSE, EDWARD, 15, Clarendon Road, Notting Hill, London, W.
HAMILTON, E., Rig Wood, Saltburn-by-the-Sea.

HAMILTON, G., c/o B. S. Lloyd and Co., 78, Queen Victoria Street, London, E.C.
HAMILTON, J. P., Loscoe Brook, Codnor, Derby.
HANCOCK THOMAS, Bagnall House, Nottingham.
HANN, EDMUND, Aberaman, Aberdare.
HARBOTTLE, W. H., Orrell Coal and Cannel Co., near Wigan.
HARDWICK, Frederick, Eckington Collieries, Rotherham.
HARE, SAMUEL, Bedlington Collieries, Bedlington, R.S.O., Northumberland.
HARGREAVES, J., Rothwell Haigh Colliery, Leeds.
HARGREAVES, WILLIAM, Rothwell Haigh Colliery, Leeds.
HARKER, WM., 17A, Great George Street, Westminster, London, S.W.
HARLE, RICHARD, Browney Colliery, Durham.
HARLE, WILLIAM, Pagebank Colliery, near Durham.
HARPER, H., 63, Pitt Street, Sydney, New South Wales.
HARPER, J. P., All Saints' Chambers, Derby.
HARRIS, W. S., Kibblesworth, Gateshead-upon-Tyne.
HARRISON, GEORGE, High Park Colliery, Greasley, Nottingham.
*HARRISON, R., Eastwood, near Nottingham.
HARRISON, W. B., Brownhills Collieries, near Walsall.
HASWELL COAL CO., Haswell Colliery, Haswell, *via* Sunderland.
HAWKES, J., Heathfield Road, Handsworth, Birmingham.
HAY, J., Jun., Widdrington Colliery, Acklington.
HAY, WILLIAM, Nostell Colliery, Wakefield.
HAY, W., Jun., Wood View House, Stanton, Burton-on-Trent.
HAYNES, FRANK, Birley Collieries, Sheffield.
HAYWARD, W. J., Tipton.
HEAD, JEREMIAH, Queen's Square, Middlesbrough.
HEATHCOTE, C. H., Newstead Colliery, near Nottingham.
HEDLEY, CHAS., Black Park Colliery, Chirk, Ruabon.
HEDLEY, E., Rainham Lodge, The Avenue, Beckenham, Kent.
HEDLEY, J. J., Derwent Cote House, Lintz Green Station.
HEDLEY, J. L., H.M. Inspector of Mines, 22, Hawthorn Terrace, Newcastle-upon-Tyne.
HEDLEY, T. F., Jun., Sunderland.
HEDLEY, SEPT. H., Bank Chambers, Wakefield.
HEDLEY, W. H., Consett Collieries, Medomsley, Newcastle-upon-Tyne.
HENDERSON, C. W. C., The Riding, Hexham.
HENDERSON, H., Pelton Colliery, Chester-le-Street.
HENDERSON, J. J., U.S. Engineer's Office, Kingsbridge, New York, U.S.A.
HENDY, J. C. B., Pleasley Colliery, Mansfield, Notts.
HENSHAW, A. MAYON, Talk-o'-th'-Hill Colliery, Stoke-on-Trent.
HENZELL, ROBERT, Close, Newcastle-upon-Tyne.
HEPBURN, T., Langley Park, Durham.
HEPPELL, T., Leafield House, Birtley, Chester-le-Street.
HEPPLEWHITE, W. H., H.M. Inspector of Mines, Roscius House, Corporation Oaks, Nottingham.
HESLINGTON, ALFRED, New Tupton, Chesterfield.
HESLOP, C., Upleatham and Lingdale Mines, Upleatham, R.S.O., Yorkshire.
HESLOP, GRAINGER, Deptford Hall, Sunderland.
HESLOP, JAMES, Sherwood, Nottingham.
HESLOP, THOMAS, Storey Lodge Colliery, Cockfield, *via* Darlington.
HETTON COAL COMPANY, Fence Houses.

HEWITT, C. R., London Road, Derby.
HEWITT, GEORGE, Unstone, Sheffield.
HEWITT, G. C., Coal Pit Heath Colliery, near Bristol.
HEWITT, H. R., H.M. Inspector of Mines, 47, Hartington Street, Derby.
HEWITT, T. P., Swadlincote and Cadley Hill Collieries, Burton-on-Trent.
HEWLETT, A., Haseley Manor, Warwick.
HICKMAN, E., Stone Quarries, Bilston.
HICKS, Prof. W. M., Firth College, Sheffield.
HIGSON, JACOB, Messrs. J. and P. Higson, 18, Booth Street, Manchester.
HIGSON, JOHN, Oak Bank, Lancaster Road, Eccles, Manchester.
HILL, WILLIAM, Carterthorne Colliery Offices, Witton-le-Wear.
HILTON, J., 72, Hawkshead Street, Southport.
HILTON, T. W., Wigan Coal and Iron Co., Limited, Wigan.
HINCHLIFFE, J., Bullhouse Colliery, Penistone, near Sheffield.
HODGKINSON, ALBERT, The Laurels, Woollaton, Nottingham.
HODGSON, J., Edmondsley Colliery, Chester-le-Street.
HOLDING, WILLIAM, Cossall Colliery, Nottingham.
HOLDSWORTH, THOMAS, Clay Cross, Chesterfield.
HOLFORD, W. D., Whittington, Chesterfield.
HOLLIDAY, MARTIN F., Langley Grove, Durham.
HOLLIDAY, T., Joan Royd Colliery, Heckmondwike.
HOLLIS, HENRY WM., North Lodge, Darlington.
HOLMES, C., Grange Hill, near Bishop Auckland.
HOLT, FRANCIS, Midland Railway Locomotive Department, Derby.
HOMER, CHARLES J., Stoke-on-Trent.
HOOD, A., 6, Bute Crescent, Cardiff.
HOOPER, ED., c/o J. H. Hooper, College Precincts, Worcester.
HOPKINS, EDWARD, 13, Harrington Gardens, London, S.W.
HOPKINSON, HENRY, Station Street, Nottingham.
HOPPER, J. I., Tyne Dock, South Shields.
HORSLEY, W., Whitehill Point, Percy Main, Newcastle-upon-Tyne.
HOSKOLD, H. D., Inspector-General of Mines of the Argentine Republic, and Director of the National Department of Mines and Geology, Casilla, Correos, 900, Buenos Ayres.
HOUFTON, CHARLES, Heathfield Villas, Garforth, Leeds.
HOUFTON, J. P., Bolsover Colliery, Chesterfield.
HOUGH, JOHN, Pelsall.
HOWARD, W. F., 15, Cavendish Street, Chesterfield.
HOWDEN, THOMAS, Wakefield.
HOWE, GEORGE, Clay Cross, Chesterfield.
HOWE, WM., Clay Cross, Chesterfield.
HOWL, E., The Quarries, Dudley, Worcestershire.
HUBBERSTY, H. A., Burbage, Buxton.
HUGHES, H. W., Priory Farm House, Dudley, Worcestershire.
HUGHES, J., Dudley, Worcestershire.
HUGHES, THOMAS GEORGE, Blackwell, Alfreton.
HUMBLE, JOSEPH, Markham Collieries, Duckmanton, Chesterfield.
HURST, GEORGE, 58, Eldon Street, Newcastle-upon-Tyne.
HUTCHINSON, T. C., Hilda House, Middlesbrough.
HUTT, E. H., Holdfast Main Reef Gold Mining Co., Limited, Boksburg, Z.A.R.
HUTTON HENRY COAL COMPANY, LIMITED, 7, Bondgate, Darlington.

IRVINE, JOSEPH R., Hendon Ropery, Sunderland.

JACKSON, A., Howley Park Colliery, Batley.
JACKSON, JOHN, Stubben Edge, Chesterfield.
JACKSON, W. B. M., Clay Cross Hall, Chesterfield.
JACKSON, W. G., Hicklam House, Aberford, near Leeds.
*JAMES, D., Ruabon.
JAMESON, THOMAS, Wharncliffe Silkstone Colliery, Barnsley
JARRATT, J., Houghton Main Colliery, Barnsley.
JEFFCOCK, C. E., Birley Colliery, Sheffield.
JEFFCOCK, T. W., 18, Bank Street, Sheffield.
JEFFERY, G. F., 44, Park Square, Leeds.
JENKINS, W., Ocean Collieries, Treorky, Glamorgan.
JENKINS, WM., Consett Iron Works, Consett, Durham.
JEPSON, H., 20, The Avenue, Durham.
JEUDWINE, W. W., Abercrombie Street, Chesterfield.
JOBLING, T. E., Croft Villa, Blyth, Northumberland.
JOHNSON, F. D., Aykleyheads, Durham.
JOHNSON, H., Trindle Road, Dudley, South Staffordshire.
JOHNSON, J., Carlton Main Colliery, Barnsley.
*JOHNSON, R. S., Sherburn Hall, Durham.
JOHNSON, W., Abram Colliery, Wigan.
JOHNSON, WM., Radcliffe Colliery, Acklington, Northumberland.
JOICEY, J. G., Forth Banks West Factory, Newcastle-upon-Tyne
JOICEY, W. J., Sunningdale Park, Berkshire.
JONES, E., Whitwell Colliery, Whitwell, Chesterfield.
JONES, F. J., Rother Vale Colliery, Treeton, Rotherham
JONES, GEORGE, The Hall, Bloxwich.
JONES, JOHN, Shire Oaks Colliery, Worksop.
JONES, LLOYD, Ruabon.

KAYLL, A. C., Gosforth, Newcastle-upon-Tyne.
KEEP, R. S., Horsley and Co., Tipton.
KELL, G. J., Park Road, Barnsley.
KELLET, M. H., Castle Eden Colliery, near Castle Eden.
KELLETT, WILLIAM, Portland Bank, Southport.
KENRICK, JOHN P., 37, Westwood Street, Moss Side, Manchester.
KESTEVEN, FRANK, Monckton Main Colliery, Barnsley.
KETLEY, J. H., Glynthurst, Yardley, near Birmingham.
KIRKBY, J. W., Kirkland, Leven, Fife.
KIRKHOUSE, E. G., 1, Edith Street, Consett, Co. Durham.
KIRKUP, J. P., Pelton House, Chester-le-Street.
KIRKUP, PHILIP, Cornsay Colliery Office, Esh, near Durham.
KIRTON, HUGH, Waldridge Colliery, Chester-le-Street.
KNIGHTON, H. A., Bagworth, Leicester.
*KNOWLES, A., Swinton Old Hall, Manchester.
KNOWLES, JOHN, Westwood, Pendlebury, Manchester.
KNOWLES, ROBERT, Ednaston Lodge, near Derby.

LAMB, GEORGE, Butterley Park Collieries, Alfreton.
LAMB, R., Bowthorn Colliery, Cleator Moor, Whitehaven.

LAMB, R. O., The Lawn, Ryton-on-Tyne.
LAMB, RICHARD W., 29, Great Cumberland Place, London, W.
*LAMPEN, G. J., Wakefield.
LANCASTER, JOHN, Anfield House, Leamington.
LANCASTER, JOHN, Auchinheath, Southfield and Fence Collieries, Lesmahagow, N.B.
LANDALE, A., Comely Park Place, Dunfermline.
LAPORTE, H., Flénu, near Mons, Belgium.
LAVERICK, J. H. W., Riddings Colliery, near Alfreton.
LAVERICK, JAS., East Gawber Colliery, Barnsley.
LAVERICK, JOHN WALES, Tow Law Colliery Office, Tow Law, R.S.O., Co. Durham.
LAVERICK, ROBT., West Rainton, Fence Houses.
LAWLEY, J., Cradley Heath
LAWRENCE, H., Grange Iron Works, Durham.
LAWS, W. G., Town Hall, Newcastle-on-Tyne.
LAWTON, WM., 98, Kirkmanshulme Lane, Longsight, Manchester.
LEA, H., Bennett's Hill, Birmingham.
LEACH, C. C., Seghill Colliery, Northumberland.
LEAVER, J. R., 13, Brookfield Terrace, Swansea.
LEE, JOHN F., Castle Eden Colliery, Co. Durham.
LEES, T. G., Clifton Colliery, Nottingham.
LEWIS, GEORGE, Imperial Chambers, Albert Street, Derby.
LEWIS, HENRY, Annesley Colliery, Nottingham.
LEWIS, Sir WILLIAM THOMAS, Mardy, Aberdare.
LIDDELL, J. M., 3, Victoria Villas, Newcastle-upon-Tyne.
LINDLEY, EDWARD, Eastwood, Nottingham.
LINDOP, J., Lime Tree House Bloxwich.
LINSLEY, R., Cramlington Colliery, Northumberland.
LINSLEY, S. W., Whitburn Colliery, South Shields.
LISHMAN, R. R., Durham Main Colliery, Durham.
LISHMAN, T., Jun., Hetton Colliery, Fence Houses.
LISHMAN, WM., Bunker Hill, Fence Houses.
LISHMAN, WM., Holly House, Witton-le-Wear.
LISLE, J., De Beers Mine, Kimberley, South Africa.
LIVEING, E. H., 52, Queen Anne Street, Cavendish Square, London, W.
LIVERSEDGE, W. G., Norfolk Road, Sheffield.
LIVESEY, C., Bradford Colliery, near Manchester.
LIVESEY, T., Bradford Colliery, near Manchester.
LLEWELLIN, DAVID MORGAN, Glanwern Offices, Pontypool.
LOGAN, WILLIAM, Langley Park Colliery, Durham.
LONDONDERRY, Marquess of, c/o V. W. Corbett, Esq., Londonderry Offices. Seaham Harbour.
LONGBOTHAM, J., Barrow Collieries, Barnsley, Yorkshire.
LONGBOTHAM, R. H., 15, Westgate, Wakefield.
LONGDEN, J. A., Teversal, Mansfield.
LONGRIDGE, J., Coxlodge Colliery, Newcastle-upon-Tyne.
LOWDEN, T., Hamsteels, near Durham.
*LOWRANCE, J., Peel Square, Barnsley.
LUCAS, SAMUEL, Dronfield Foundry, Dronfield, Sheffield.
LUPTON, Prof. A., 6, De Grey Road, Leeds.
LYON, J., Walsall Wood, Walsall.

MacCabe, H. O., Russell Vale, Wollongong, New South Wales.
MacIntosh, T., Waterloo, Blyth.
Maddison, Thos. R., Dirtcar House, near Wakefield.
Maddison, W. H. F., The Lindens, Darlington.
Makepeace, H. R., H.M. Inspector of Mines, Newcastle, Staffordshire.
Maling, C. T., Ellison Place, Newcastle-upon-Tyne.
Mammatt, J. E., St. Andrew's Chambers, Leeds.
Markham, C. P., Broad Oaks Iron Works, Chesterfield.
Markham, G. E., Howlish Offices, Bishop Auckland.
Marley, J. W., Thornfield, Darlington.
Marriott, Joseph, Jun., Pilsley Colliery, Clay Cross, Chesterfield.
Marsh, F. S., Hall End Colliery, Tamworth.
Marsh, T G., 2, Priory Street, Dudley, Worcestershire.
Marshall, F. C., Messrs. R. and W. Hawthorn, St. Peter's, Newcastle-upon-Tyne.
Marshall, J. L., Monk Bretton Colliery, Barnsley.
Marshall, W., Liversedge Colliery, Liversedge, *via* Normanton.
Marshall, W. B., Richmond Hill, Edgbaston, Birmingham.
Marten, E. B., Pedmore, near Stourbridge.
Marten, H. J., The Birches, Codsall, near Wolverhampton.
Martin, Gilson, Edensor, Chesterfield.
Martin, R. F., Mountsorrel, Loughborough.
Martin, Tom Pattinson, Allhallows Colliery, Mealsgate, Carlisle.
Mason, Benj., Burnopfield, R.S.O., Durham.
Matthews, J., Messrs. R. and W. Hawthorn, Newcastle-upon-Tyne.
Matthews, R. F., Harehope Hall, Alnwick.
Maughan, J. A., Manager of the Government Central Provinces Collieries, Umaria, *via* Katni, India, C.P.
May, G., Harton Colliery Offices, near South Shields.
May, T. H., Dronfield, Sheffield.
Maydew, Benj., Lyme House, Whiston, Prescott.
McAdoo, John.
McCarthy, E. T., Eloiyang, Gleneldon Road, Streatham, London, S.W.
McCreath, J., 208, St. Vincent Street, Glasgow.
McCulloch, David, Beech Grove, Kilmarnock, N.B.
McLaren, B., Heddon Coal and Fire Brick Co., Wylam-upon-Tyne.
McMurtrie, G. E. J., Foxes Bridge Colliery, Cinderford, Gloucestershire.
McMurtrie, J., Radstock Colliery, Bath.
Meacham, F. G., Red House, Hall Green, Wednesbury.
Melling, Wm., South Leicestershire Colliery, Coalville, Leicestershire.
Mellors, James, H.M. Inspector of Mines, Leeds.
Melly, E. F., Griff Colliery, Nuneaton.
Merivale, Prof. J. H., M.A., 2, Victoria Villas, Newcastle-upon-Tyne.
Merivale, W., The Deanery, Ely.
Meysey-Thompson, A. H., Sun Foundry, Leeds.
*Middleton, E., Outwood House, Wakefield.
Middleton, Francis Ed., Lofthouse, Wakefield.
Miles, Wm. Hy., 23, Barnato Buildings, Johannesburg, Transvaal, South Africa.
Miller, N., 31, Hyde Lane, Hyde, near Manchester.
*Miller, R., Beech Grove, Locke Park, Barnsley.
Mills, M. H., 65, Station Street, Nottingham.
Mills, S. B., Pensnett, Dudley, Worcestershire.

MILNE, Prof. JOHN, University of Tokio, Japan.
MITCHELL, CHAS., Jesmond, Newcastle-upon-Tyne.
MITCHELL, JOSEPH, Mining Offices, Barnsley.
MITCHELL, T. W. H., Mining Offices, Barnsley.
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MOORE, R. W., Somerset House, Whitehaven.
MOORE, WILLIAM, Loftus Mines, Loftus-in-Cleveland, R.S.O.
MORDY, W., Kimblesworth Colliery, Chester-le-Street.
MOREING, C. A., Suffolk House, Laurence Pountney Hill, London, E.C.
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MORGAN, TOM, Klerksdorf, South Africa.
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MUNDLE, ARTHUR, St. Nicholas' Chambers, Newcastle-upon-Tyne.
*MUNDLE, W., Redesdale Mines, Bellingham.
MURTON, CHAS. J., Delaval Benwell Colliery, Newcastle-upon-Tyne.
MUSCHAMP, PERCIVAL, Warren Grove, Sheffield Road, Barnsley.
MUSGRAVE, HENRY, Havercroft Main Colliery, Roystone, near Barnsley.

NASH, H. B., Clarke's Old Silkstone Colliery, Barnsley.
NASSE, RUDOLPH, Geheimerbergrat, Dornsbergstrasse, 6, Berlin, W., Germany.
NAYLOR, HY., Stairfoot, Barnsley.
NEVIN, JOHN, Littlemoor House, Mirfield.
NEWBOULD, T., Low Stubbin Colliery, Rawmarsh, Rotherham.
NEWEY, J. W., Wellington Road, Dudley, Worcestershire.
NICHOLSON, A. D., Elemore Colliery, Fence Houses, Co. Durham.
NICHOLSON, J. H., Seaton Delaval Colliery, Northumberland.
NICHOLSON, MARSHALL, Middleton Hall, Leeds.
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NORTH BRANCEPETH COAL CO., LIMITED, 7, Bondgate, Darlington.
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OAKES, C. H., Holly Hurst, Alfreton.
OATES, ROBERT J. W., Manager, Rajdoha Mining Co., Limited, *via* Kandra P.O., Bengal Nagpur Railway, Bengal, India.
OGDEN, J. M., Sunniside, Sunderland.
OGILVIE, A. GRAEME, 8, Grove End Road, St. John's Wood, London.
OLIVER, C. J., Spring Vale, Spital, Chesterfield.
ORNSBY, R. E., Seaton Delaval Colliery, Newcastle-upon-Tyne.
OTTEWELL, DRAPER, The Gardens, Osmaston Road, Derby.
OVEREND, JAMES, Mining Offices, Barnsley.

PALMER, Sir CHAS. MARK, Bart., M.P., Quay, Newcastle-upon-Tyne.
PALMER, A. S., Highfield House, Gateshead-upon-Tyne.
PALMER, HENRY, East Howle Colliery, near Ferryhill.
PAMELY, C., 21, Morgan Street, Pontypridd, South Wales.
PANTON, F. S., Silksworth Colliery, Sunderland.
PARKIN, J., Rylands Main Colliery, Barnsley.
PARKINSON, W., 5, Elm Street, South Moor, Chester-le-Street.
PARRINGTON, M. W., Wearmouth Colliery, Sunderland.
PARRY, EVAN, Wharncliffe Woodmoor Colliery, Barnsley.
PARSONS, Hon. CHARLES ALGERNON, Elvaston Hall, Ryton-upon-Tyne.
PARTRIDGE, H. H., Dunstan House, Elmdon, Birmingham.
PASFIELD, T., Wellington Road, Dudley, Worcestershire.
PATTERSON, THOMAS, Craghead, Chester-le-Street.
PATTISON, WM., Morley Main Colliery, Morley, near Leeds.
PAYTON, EDMUND, Yew Tree House, Morleston Street, Derby.
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PEAKE, H. C., Walsall Wood Colliery, Walsall.
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*PEARCE, F. H., Westleigh, Harrogate.
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PEILE, WILLIAM, Cartgate, Hensingham, Whitehaven.
PENDLETON, W. B., Harris Road, Five Dock, Sydney, New South Wales.
PERCY, W. R., Rock House, Barnsley.
PHILLIPS, JOHN, West Bromwich.
PHILLIPS, W. G., Ansley Hall Colliery, Atherstone, Warwickshire.
PICKUP, P. W., 71, Preston New Road, Blackburn.
PIERCEY, H., Broad Street, Birmingham.
PIGGFORD, JONATHAN, Sheepbridge Offices, Sheepbridge, Chesterfield.
PLOWRIGHT, R., Brampton Ironworks, Chesterfield.
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POLLARD, JOHN, Central Chambers, King Street, Wakefield.
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RAMSAY, J. A., Sherburn and Littletown Collieries, near Durham.
RAMSAY, W., Tursdale, Co. Durham.
RATHBONE, EDGAR P., P.O. Box 563, Johannesburg, Transvaal, South Africa.
REDMAYNE, R. A. S., Ingagane Railway Station, near Newcastle, Natal, South Africa.
REDMAYNE, R. NORMAN, Chemical Manufacturer, &c., 26, Grey Street, Newcastle-upon-Tyne.
REID, ANDREW, Newcastle-upon-Tyne.
REYNOLDS, JOHN JAMES, 86, Harrol Terrace, Swinton, Lancashire.
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RHODES, W. L., St. Peter's Road, Handsworth, Birmingham.
RICH, WM., Minas de Rio Tinto, Provincia de Huelva, Spain.
RICHARDSON, A. M., 44, Victoria Road, Leeds.
RICHARDSON, H., Backworth Colliery, Newcastle-upon-Tyne.
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RIDLEY, G., 16, Dean Street, Newcastle-upon-Tyne.
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RITSON, J. R., Jesmond Gardens, Newcastle-upon-Tyne.
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ROBERTS, SAMUEL, Park Grange, Sheffield.
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ROGERS, D., Dudley Road, Tipton.
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ROSSER, W., Rhydyrhelig, Sketty, Swansea.
ROTHWELL, R. P., 27, Park Place, New York, U.S.
ROUTLEDGE, J. L., Waterloo Main Colliery, near Leeds.

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SANKEY, W. H., Sandiacre, Nottingham.
SAWYER, A. R., P.O. Box 1,030, Johannesburg, Transvaal. Transactions to 40, Brompton Square, London, S.W.
SCARTH, W. T., Raby Castle, Staindrop, Darlington.
SCHOLEFIELD, JOHN, Kimberley, Notts.
SCHRAM, RICHARD, 17A, Great George Street, Westminster, London, S.W.
SCOTT, ANDREW, Broomhill Colliery, Acklington.
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SCOTT, WALTER, 46, Senhouse Street, Maryport.
SCOTT, WM., Brancepeth Colliery Offices, Willington, Co. Durham.
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SHINTON, JAMES, 8, Broadwell Road, Oldbury.
SHIPLEY, T., Woodland Colliery Office, Woodland, Butterknowle, R.S.O., Co. Durham.
SHONE, ISAAC, Great George Street Chambers, Parliament Square, London, S.W.
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SMITH, T. E., Phœnix Foundry, Newgate Street, Newcastle-upon-Tyne.
SNOW, CHARLES, Glapwell Colliery, near Chesterfield.
*SNOWBALL, JOSEPH. Seaton Burn House, Dudley, Northumberland.
SNELL, ALBION T., Brightside, Salisbury Road, Brondesbury, London, N.W.
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SOPWITH, ARTHUR, Chasetown, near Walsall.
SOPWITH, THOS., 6, Great George Street, Westminster, London, S.W.
SOUTH HETTON and MURTON COLLIERIES, OWNERS OF, 50, John Street, Sunderland.
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SOUTHERN, R., Burleigh House, The Parade, Tredegarville, Cardiff.
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Steavenson, A. L., Durham.
Steavenson, C. H., Brotton Mines, Brotton, R.S.O., Yorks.
Stechert, G. E., 30, Wellington Street, London, W.C.
Stella Colliery, Owners of, Hedgefield, Blaydon-upon-Tyne.
Stephenson, G. R., 9, Victoria Chambers, Westminster, London, S.W.
Stephenson, W., Garesfield Colliery, Lintz Green.
Stevens, James, 9, Fenchurch Avenue, London, E.C.
Stevenson, Henry, Portland Collieries, Alfreton.
Stobart, F., Biddick Hall, Fence Houses.
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Stones, George, Denaby Main Colliery, Mexboro', Rotherham.
Storey, Thos. E., Clough Hall Iron Works, Kidsgrove, Staffordshire.
Strachan, Alexander, 131, Station Street, Burton-on-Trent.
Straker, J. H , Stagshaw House, Corbridge-upon-Tyne.
Stratton, T. H. M., Cramlington House, Northumberland.
Streatfield, Hugh S., Ryhope Colliery, near Sunderland.
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Sutcliffe, A. T., Manor Terrace, Eckington, Rotherham.
Sutton, William, Hemsworth, Wakefield.
Swallow, J., Bushblades House, Lintz Green, Newcastle-upon-Tyne.
Swallow, J. F., Mosboro' Hill House, Eckington, Rotherham.
Swallow, R. T., Wardley Hall, Newcastle-upon-Tyne.
Swan, H. F., Beaufront Castle, Hexham.
Swan, J. G., Upsall Hall, near Middlesbrough.
Swann, C. G., Secretary, General Mining Association, Limited, New Broad Street, London, E.C.
Swann, Frank, Annesley, Nottingham.
Sykes, Frank K., Springwell Villa, Bishop Auckland.

Tate, Simon, Trimdon Grange Colliery, Co. Durham.
Tate, William, West Ardsley Collieries, Wakefield.
Taylor, Hugh, King Street, Quay, Newcastle-upon-Tyne.
Taylor, John Hy., Borough Surveyor, Barnsley.
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Thompson, Charles Lacy, Farlam Hall, Milton, Carlisle.
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TOMLIN, JOHN, Granville Colliery, Burton-on-Trent.
TOMLINSON, JOHN, Pilsley Colliery, Clay Cross, Chesterfield.
TOPLEY, WM., 28, Jermyn Street, London, S.W.
TREGLOWN, C. H., Wretham Road, Handsworth, Birmingham.
TRENCH, W. G., c/o Mr. G. Trench, Cotton Powder Co., Faversham, Kent.
TURBUTT, W. G., Ogston Hall, Alfreton.
TURNBULL, ROBERT, South Kirkby Colliery, Wakefield.
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TWIGG, R., East Cannock Colliery, Hednesford.
TYAS, A., Swaith, near Barnsley.
TYERS, JOHN E., Nerbudda Coal and Iron Company, Limited, Mohpani Coal Mines, *via* Gadawarra, C. Provinces, India.
TYZACK, D., 71, Westgate Road, Newcastle-upon-Tyne.

VARLEY, JOHN, Park View, Hill Top, Eastwood, Notts.
VARTY, THOMAS, Skelton Park Mines, Skelton, R.S.O., Cleveland.
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WALKER, HY. S., Netherthorpe Worksop.
WALKER, J. S., Pagefield Iron Works, Wigan, Lancashire.
WALKER, SYDNEY FERRIS, 196, Severn Road, Canton, Cardiff.
WALKER, W., Hawthorns, Saltburn-by-the-Sea.
WALKER, WM., Jun., H.M. Inspector of Mines, Durham.
WALKER, W. E., Dudley, Worcestershire.
WALKER, WILLIAM EDWARD, Lowther Street, Whitehaven.
WALLACE, HENRY, Trench Hall, Gateshead-upon-Tyne.
WALLACE, J., King Street, Wigan.
WALLAU, JACOB, Messrs. Black, Hawthorn, and Co., Gateshead-upon-Tyne.
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WALTON, W. W., Croft Cottage, Ferryside, near Carmarthen, South Wales.
WARBURTON, J. S., 49, New Road, Greys, Essex.
WARD, H., Rodbaston Hall, near Penkridge, Stafford.
WARD, T. H., Burwadi Bungalow, Giridih, E.I.Ry., Bengal, India.
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WEIGHTMAN, PERCY O., Sheffield Road, Woodhouse, near Sheffield.
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WHITEHOUSE, W. H., Brownhills, Walsall.
WHITELAW, JOHN, 118, George Street, Edinburgh.
WHITING, S. B., Calumet, L.S., Michigan, U.S.A.
WHITTEM, THOMAS S., Wyken Colliery, near Coventry.
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WILKINSON, THOMAS, Clay Cross, Chesterfield.
WILKINSON, THOMAS, Tinsley, near Sheffield.
WILLIAMS, J., 115, Wellington Road, Dudley.
WILLIAMSON, J., Cannock Wood, Hednesford.
WILLIAMSON, J. T., Brownhills Colliery, Walsall.
WILLIAMSON, R. S., Cannock Wood, Hednesford.
WILLIAMSON, THOMAS, West Hallam Collieries, Ilkeston.
WILSON, A. P., Mansion House Chambers, Queen Victoria Street, London, E.C.
WILSON, J. B., Wingfield Iron Works and Colliery, Alfreton.
WILSON, J. D., Ouston House, Chester-le-Street.
WILSON, JOSH. M., St. John's Colliery, Normanton.
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WINSTANLEY, ROBT., 28, Deansgate, Manchester.
WINTER, T. B., Grey Street, Newcastle-upon-Tyne.
WINTERBOTTOM, W., Teversal, Mansfield.
WITHERS, SAMUEL, 26, Westgate, Mansfield.
WITTY, H. SYKES, Denaby Main Colliery, Mexboro', near Rotherham.

WOOD, C. L., Freeland, Forgandenny, Perthshire.
WOOD, JOHN, Coxhoe Hall, Coxhoe, R.S.O., Co. Durnam
WOOD, LINDSAY, The Hermitage, Chester-le-Street.
WOOD, THOMAS, Rainton House, Fence Houses.
WOOD, T. P., Market Place, Chesterfield.
WOOD, W. H., Coxhoe Hall, Coxhoe, Co. Durham.
WOOD, W. O., South Hetton, Sunderland.
WOODHEAD, E., Low Moor Ironworks, Bradford.
WOODHEAD, L., Beeston Colliery, Leeds.
WOODIWISS, ALFRED, Belair, Trafalgar Road, Birkdale, near Southport.
WOOLCOCK, HENRY, St. Bees, Cumberland.
WORDSWORTH, ROBERT, St. John's Colliery, Normanton.
WORMALD, C. F., Mayfield Villa, Saltwell, Gateshead-upon-Tyne.
WRIGHT, FITZ-HERBERT, The Hayes, Swanwick, Alfreton.
WRIGHT, JOSEPH, Arboretum Street, Nottingham.
WRIGHTSON, T., Stockton-on-Tees.
WROE, JAMES, Lidgett Colliery, Tankersley, Barnsley.
WROE, JONATHAN, St. John's Colliery, Staveley, Chesterfield.

YATES JOHN, 52, Lower Broughton Road, Lower Broughton, Manchester.
YEOMAN, T., Willington Colliery, Co. Durham.
YOUNG, JOHN A., 7, Tyne Vale Terrace, Gateshead-upon-Tyne.

ZUMBULOGLON, G. C., 3, Astardji han, Grand Bazaar, Constantinople.

TRANSACTIONS.

OF THE

FEDERATED INSTITUTION OF MINING ENGINEERS.

MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD AT THE QUEEN'S HOTEL, LEEDS, DECEMBER 16TH, 1890.

MR. T. W. EMBLETON, PAST-PRESIDENT, IN THE CHAIR.

The CHAIRMAN—I am very sorry our President (Mr. Jos. Mitchell) is not able to attend to read his inaugural address. He telegraphs to his son as follows:—"I am too unwell to attend the meeting to-day, please explain and read my address."

The minutes of the last meeting were read and confirmed.

The following gentlemen were elected Members of the Institute, having been previously nominated:—

Mr. George Fitton, Colliery Manager, Wortley, Sheffield.

Mr. James Laverick, Colliery Manager, East Gawber Colliery, Barnsley.

Mr. Joseph Longstaffe Routledge, Colliery Manager, Waterloo Main Collieries, Leeds.

Mr. Henry Naylor, Civil and Mining Engineer, Silkstone and Dodworth Collieries, Barnsley.

Mr. C. Dickenson, Mining Engineer, Houghton Main Colliery, Barnsley.

The President's inaugural address was read as follows:—

PRESIDENTIAL ADDRESS.

By Mr. Joseph Mitchell, M. Inst. C.E., F.G.S.

Gentlemen,—Permit me, in the first place, to record the great honour I feel you have done me in electing me your President for the ensuing year, and to assure you that I shall ever use my best endeavours to further its interests, at the same time I fear I may not be able to fulfil the duties in the same satisfactory manner as some of your Past-Presidents have done.

As Secretary for eleven years I have always taken a deep interest in the welfare of the Institute, and have watched its career through serious financial difficulties to its present hopeful condition.

The Institute has now become associated with other institutes—viz., The North of England, Chesterfield and Midland Counties, and the South Staffordshire, under the title of the Federated Institution of Mining Engineers. There have been three meetings of the Federated Institution, but the full benefits of the amalgamation have not yet been realised, the principal reasons being that the President (Mr. John Marley) was taken ill in July, and the Hon. Secretary (Professor Lebour) has also been suffering from indisposition.

To make this Institute as successful in the future as in the past, and also to develop the Federated Institution, I would urge upon the members to contribute as many papers as possible upon the various subjects connected with and incidental to mining and mechanical engineering, especially those daily affecting the working of mines, and this remark would also apply to any better method of dealing with the workmen, so as to prevent strikes and other consequent troubles.

From the Council's report it appears that twelve papers were read during the past year, and that the accounts are in a satisfactory condition. The Council, in their report, call special attention to the necessity of members contributing papers upon mechanical appliances for haulage, pumping, and other means, especially electricity, and also any invention which will prevent sparking, that being, in the opinion of all mining engineers, a great drawback where electricity is used under the water-bearing strata in fiery mines.

The Council also point out that the papers of the Federated Institution are open for discussion at the meetings of this Institute; this is a great advantage, and one which the members should avail themselves of.

It is hoped that the Joint Committee's report on fan experiments will be completed very shortly, as it promises to be a very exhaustive and important document.

There have been several new explosives introduced during the past year, one of which is the Giffard explosive, but this, in my opinion, is an explosive which could not possibly be used in a mine, as the fumes from the exploded gas would be of such a nature as to be injurious to the health of any person working in the return immediately adjacent; it is without flame and practically noiseless; it is stored liquefied carbonic acid gas. There is another explosive that has not yet been

brought out publicly, and which is of a dynamite character, but is of such a mixture as not to be affected by extreme temperatures, therefore it does not explode spontaneously, yet shows a flame when exploded.

Great difficulty is experienced by having to use bad water for steam-raising. I have seen two appliances—one, Bower's Separator, and another, Carroll's Purifier. The action of the former is to deal with the water inside the boiler, separating and collecting the scum, and then blowing it out by pipe connections and taps. The Carroll Purifier deals with the water as sent in by the feed pipes, through two channels; these channels are placed in the heated steam in the boiler, and the heat so applied is supposed to raise the water to such a temperature as to hold all the injurious matter in suspension, and is then blown out through taps by the pressure of the steam. We have the former at work at our collieries.

I visited the United States this autumn for the purposes of investigating the use of water-gas there, and found several systems in use for lighting purposes—part was carburetted water-gas and part pure water-gas. In Chicago we found the old gas retorts laid idle, as well as in New York. In Jackson City we found coal-gas, pure water-gas, with the magnesian combs, and the electric light, all at work in the same city, and competing at low rates. In this city the pure water-gas system has been in practical use for over 18 months; there are now over 8,000 pure water-gas lights with the magnesian combs, in a population of 20,000. It is used extensively for cooking food and heating rooms, and the people in the United States fear no evil from the effects of the large amount of carbonic oxide made so much of in this country, and the question that it was odourless, has now been set at rest so far as the United Kingdom is concerned by a provisional order granted by the Board of Trade for the lighting of Llandridnod Wells, in which mercaptan and thio-acetone have been authorised as the mediums of odourising water-gas. Sir Henry Roscoe, F.R.S., M.P., appeared before the Board of Trade for the British Water-Gas Syndicate to support the before-mentioned odourisers. An escape is now as easily detected by these odourisers as an escape of ordinary coal-gas. There is no doubt that the pure water-gas is the cheapest, and in every way to be preferred to the carburetted water-gas, as it is free from smoke, gives a clear light, and burns only half the oxygen in the atmosphere, as the ordinary coal-gas.

Sir Henry Roscoe's examination of the cost of water-gas, at the Leeds Forge, proved it to be from 4d. to 6d. per 1,000 cubic feet, in the holders, according to the quality of the fuel used. If mineral oil was used for carburetting the gas, it would, owing to the very high price of mineral oil in England as against America, bring the price up to 1s. 4d. per 1,000 cubic feet in the holders. The candle-power of the pure water-gas, with magnesian combs, is 26, and contains from 38 to 40 per cent. of carbonic oxide; the carburetted water-gas is also 26 candle-power, using the same amount of gas per hour, and contains 30 per cent. of carbonic oxide.

During the last six months I have had experiments conducted at Leeds Forge, which have proved beyond doubt, and as certified by Sir Henry Roscoe, that 75 per cent. of coal shale, mixed with 25 per cent. of gas-coke, gives the best and cheapest yield of water-gas. This is a feature which is well worth the consideration of the

members of this Institute, as it would enable them, with proper appliances, to make water-gas for colliery purposes, such as illuminating, smiths' fires, and using the producer-gas for raising steam in the boilers, also for driving gas engines, out of a material which is now thrown on to the spoil bank, viz., coal shale, as well as low grade coals.

The Consolidated Gas Co., New York, and the Mutual Gas Co., New York, were two of the largest plants visited. The Consolidated Co. were producing six and a half million cubic feet of carburetted water-gas in 24 hours, and the number of men employed was 38 as against 200 with ordinary coal retorts, and a proportionate less number of men was employed for a less quantity of gas produced at the Mutual, viz., three million cubic feet per day, thus making a great saving in both cases. This, of course, is exclusive of the number of men employed for purifying, etc.

I visited the steel works of the Illinois Steel and Iron Co., South Chicago, and there I found that the molten metal was taken from the smelting furnaces in large ladles, hauled by locomotives, and poured into Bessemer converters, and then the steel was manipulated in a Bessemer converter and afterwards poured into ingot moulds, and the ingots were put into gas reheating furnaces and afterwards into rolling mills, and railway rails 32 feet long were made on the average of one a minute.

In all cases I found that the American workmen were willing to adopt machinery in any way to effect a saving of labour and increase the output.

The colliery owners and managers are, at the present time, much agitated by the question of eight hours bank to bank for underground workmen; this, in the North of England, has been rejected by the miners, and it is a very grave question for the South and West Yorkshire miners to consider. If eight hours mean from the men leaving the bank to being drawn to the bank, the result will be a very serious curtailing of the output and consequently less wages, and in large concerns would affect the drawing to the extent of 25 per cent. less per day. It would mean that the horses and day men employed below would do 25 per cent. less work each day, while the standing cost of working the mine would be increased proportionately with the lesser quantity drawn daily.

I do not anticipate that the question will be dealt with by the imperial legislature; it would be interfering with the liberty of contract, and if once dealt with by the Legislature and the eight hours granted it might, in depressed times, be reconsidered by the Legislature and ten hours put on from bank to bank. It is quite sufficient for capital and labour to have the right to deal with their respective amalgamations and form unions, and I think that the time has now arrived that reason should prevail and the wages question discussed by a board of conciliation with an unbiassed umpire. This system has been working in the North of England for many years and has now been adopted in South Yorkshire, and it is to be hoped that good results will follow and that justifiable demands on either side will prevail.

The Permanent Relief Fund is a society well worth the best encouragement of both colliery owners and workmen generally. Its benefits to the widows and orphans of those who are accidentally killed is really a blessing, as otherwise they would have to live upon the charity of others or go to the workhouse for sustenance.

The St. John Ambulance Association should be better encouraged and more widely spread, both by owners and managers. It has become law that ambulance appliances should be provided at the mines, but it is not yet compulsory that the workmen should join the association. Good work has already been done, but there are many colliery districts where very little encouragement is given to the furtherance of the St. John Ambulance cause.

It is to be very much regretted that the Colliery Managers' Association has been formed. It was certainly thought that the mining institutes were of such a wide-spread character that they would embrace all points that could be developed, and it would be of mutual advantage to have them amalgamated with us instead of forming a separate association, and it should be the endeavour of every member of this Institute to try and get the Colliery Managers' Association to amalgamate with us, as they would not only reap the benefit of existing institutes but would have the advantage of becoming members of the Federated Institution and thereby receive the benefits of three other associations whose papers are published in our Transactions, and are open for discussion at any of the meetings.

In conclusion, I would call special attention to the following comparison of the coal trade showing the amount of coal produced in Yorkshire from 1872 to 1889:—

Year.	No. of Tons Produced.	Increase since 1872.	Increase per Cent. since 1872.
1872	14,576,000	.....	.....
1873	15,311,778	735,778	5·04
1874	14,827,313	251,313	1·72
1875	15,855,990	1,279,990	8·78
1876	15,129,506	553,506	3·79
1877	15,805,235	1,229,235	8·43
1878	15,582,283	1,006,283	6·90
1879	16,241,443	1,665,443	11·43
1880	17,468,536	2,892,536	19·84
1881	18,287,141	3,711,141	25·46
1882	18,525,406	3,949,406	27·09
1883	19,563,287	4,987,287	34·21
1884	19,220,144	4,644,144	31·86
1885	18,497,778	3,921,778	26·90
1886	19,389,336	4,813,336	33·02
1887	20,104,713	5,528,713	37·93
1888	20,576,375	6,000,375	41·16
1889	21,900,000	7,324,000	50·25

This points out that in the very near future much deeper sinkings will have to be entered upon, and as the winnings become of greater depth there will be greater risk, and consequently greater necessity for the mining engineer to prepare himself to cope with these difficulties. Thus it behoves every colliery manager, as well as the mining and mechanical engineer, to impart the knowledge that he may from day to day obtain to enable us when the time does come to be in a position to cope with such responsibilities.

I wish the Institute a most prosperous and instructive year.

Mr. NASH—I have great pleasure in proposing a vote of thanks to our President for his inaugural address. I think it is an instructive one, and if its suggestions were carried out we should have more papers in the year than we have.

Mr. NEVIN—I have great pleasure in seconding that. We all know that Mr. Mitchell has been one of the main supporters of this Institute, and has done a great deal of work for it almost since the commencement. I am sure we are all glad to have him as our President this year, and I have much pleasure in seconding the vote of thanks to him for his able address.

Mr. A. LUPTON—I should be glad to support the resolution. It is an exceedingly interesting address. It is not open to any member to criticise the President's address, so our remarks must be stopped in the attitude of praise. I was about to say it was very instructive to hear the remarks made as to the use that might be made of coal shale. There can be no doubt that the progress of science leads to the use of materials which hitherto have been regarded as waste materials. I am exceedingly interested to hear this prospect shadowed forth. With regard to the other parts of the address, they seem to me to take a wide view of the subject. The suggestions with regard to workmen's insurance seem to be fraught with wisdom and for the benefit of workmen. I also hope that his suggestions with regard to papers and the St. John Ambulance Association will meet with that acceptation from the members of this Institute, which everything that falls from the Presidential chair is, I hope, sure to receive.

The CHAIRMAN—You have heard the resolution, which I perfectly agree with but I put the resolution to the meeting.

The resolution was carried unanimously.

Mr. ROBERT MILLER read the following paper "On the Coal-field adjoining Barnsley":—

ON THE COAL-FIELD ADJOINING BARNSLEY.

By Robert Miller.

It has been said that "the coal-field near Barnsley is approaching exhaustion." So we may have heard, but to qualify this the writer may say that Barnsley is the central place for extensive coal-winnings, and at a period not far in the future. True, the Barnsley Bed has been worked out at several collieries, and in the immediate vicinity of Barnsley it is in fact exhausted.

But that does not prove that there are no other seams of coal in the neighbourhood of Barnsley. If we examine the sections and sinkings below the Barnsley Bed we find there are six or seven different beds at depths varying from 60 to 435 yards, below the Barnsley Bed, viz., the Swallow Wood Coal, the Fenton Coal, the Flockton, and Parkgate, the Silkstone Coal, and the Whinmoor Coal at 65 yards below the Silkstone. This bed has been found to be very good at the Wharncliffe Silkstone Colliery, and is now being worked there; its thickness being about 3 feet.

The other beds from the Silkstone upwards have been extensively worked in the neighbourhood of Wharncliffe Silkstone by Messrs. Newton, Chambers, & Company, and also in the vicinity of Barnsley by the Barrow Coal Company, and at Hoyland.

Now, the question has been asked, why have not those beds been proved and worked close to Barnsley? and the answer is that our forefathers began to work at the top of the tree for most profit, but in so doing they carried the water down with them, and when the coal was exhausted have left the water there. Now, this water stands much in the way of winning the deeper seams, nevertheless the writer thinks that they, or some of them, will be sunk to at no distant date, and if some plan could be devised to deal with the water now, sinking might be proceeded with.

To look at it boldly, then, there is the Pindar Oaks Colliery, perhaps furthest to the dip, and with two 9 feet shafts to the Barnsley Seam, 226 yards in depth, and the water is now standing within 50 yards of the pit top. The writer will perhaps be reminded that the water from some other disused collieries flows to Pindar Oaks Colliery, but he will anticipate that by saying that the water from the Darley Main, Martin's Main Collieries, and perhaps from Smithies' Colliery, has access to Pindar Oaks, and this fact carries the great difficulty in dealing with the water during the sinking. In looking at this scheme in the most hopeful manner we are bound to say that the best plan would be to sink to the deepest of the seams underlying the Barnsley seam from the surface to a depth of more than 600 yards to the Whinmoor Seam.

At Pindar Oaks 226 yards of sinking have been done, and the shafts remain, though nearly full of water. Now, one thing the writer would suggest, that if speculators would buy the shafts, with the boilers, engines, and plant now at the colliery, the water might be pumped out.

Some gentleman may reply that the quantity of water is too large to be dealt

with there, and to this the writer begs to say that another pit at Mount Osborne, which is 800 yards to the north-west of Pindar Oaks Colliery, can be used for pumping the water if a plant was erected there.

It may be noted here that the writer has no doubt that the shafts, both at Pindar Oaks and Mount Osborne Collieries, and the plant can be obtained for a fair consideration from their present owners.

It may seem a difficult thing to give advice in such a matter, for it seems a large undertaking on which to advise anyone, yet let us confine our views to the Barnsley coal-field, extending, say, two miles on the north, east, and west sides of Barnsley, where the beds of coal above-mentioned have been tested towards the east, and by the Barrow, Hoyland, and other large collieries to the west, and where three or four of the above-mentioned seams are at present being worked. On the north side these seams have not yet been proved, but there is reason to expect that at such greater depth there may be found good or fair seams of coal; besides all this there is coal on the east or dip side, which is whole and extends over a large area. To the west we know that those seams become, within about a mile from Barnsley, divided, and are not distinguished by the names applied to them at Barnsley.

To confine our views to Barnsley and immediately about, say an area of a few square miles; what the writer would suggest for the present is, that those six or seven beds of coal ought not to be abandoned or given up; while our commerce is continually being enlarged, and as it grows and supports the application of new means and a larger system, the probability is that the demand upon our supplies of coal, which is such an essential factor in all progress, will increase and grow as the time goes on with all the appliances to power, whether to steamships, or to railways and other appliances where the first power rests with the initial coal.

The writer may also remark that after the shafts at Pindar Oaks have been lined with tubbing no more water will have to be pumped below the Barnsley Bed.

This being so, it is thought that by stating that six or seven beds of coal lie at a depth under the Barnsley Bed of 60 to 435 yards, that by the pumping of this large quantity of water and then widening the two shafts at Pindar Oaks and tubbing the water from the Barnsley Bed in those two shafts to near the surface, the main difficulty is accomplished.

The writer has some right to say that the present proprietors of the shafts before alluded to would sell the plant, that would be useful in first operations; and one essential of a successful colliery enterprise is on the place, that is a branch connecting this colliery with the Manchester, Sheffield, and Lincolnshire Railway, and other facilities for landsale close to Barnsley. The statement of particulars with seams are as follows:—

Swallow Wood Coal, about 60 yards below the Barnsley Bed, 3 feet. This thickness varies and increases to the eastward.

Lidget Coal, 125 yards below the Barnsley Bed. Its thickness is 3 feet 8 inches.

Flockton Thick Coal, about 200 yards below the Barnsley Bed. Thickness, 2 feet 10 inches.

Thin Coal, about 230 yards below Barnsley Bed. Thickness, 3 feet.

Fenton Coal, about 260 yards below Barnsley Bed. Coal and bands, 8 feet.

Parkgate Coal, about 280 yards below Barnsley Bed. Thickness, about 5 feet.

Thorncliffe Thin Coal, 315 yards below Barnsley Bed. Thickness, 4 feet 6 inches.

Silkstone Coal, about 375 yards below Barnsley Bed. Thickness, including band 5 feet 2 inches.

Whinmoor Coal, about 435 yards below Barnsley Bed. Thickness, 3 feet 1 inch.

It may be further noticed that assuming that the Pindar Oaks shafts have been lined with tubbing, then there will be no water to pump below the Barnsley Bed.

This is but a rude and, perhaps, imperfect sketch, but it will be worth something if it sets anyone to think; and though this sketch may cause many adverse opinions it may lead to the accomplishment of what the writer has suggested, and prevent the fear that such a valuable coal-field as here briefly described will now or for ever be abandoned.

Mr. A. LUPTON—I think we ought to be much obliged to Mr. Miller for having been so kind as to give us the benefit of his great experience in the Barnsley district, with a view to the development of the lower seams. The fact of these lower seams existing in the neighbourhood of Barnsley is known to geologists who have explored the outcrops, and visited the collieries in the neighbourhood, as no doubt Mr. Miller has. There is no doubt that he is right in saying that the deeper seams and the upper seams also of the Barnsley district will not be left for ever unutilised in the earth, but as the march of the thick seams proceeds eastwards the march of the thinner seams will begin at the west and also follow on to the east. It is also probable that in proceeding to work the deeper seams the water in the Barnsley Bed will be tubbed out and leave the lower workings dry in the same way as in sinking through the new red sandstone, people tubbed out the water and found the seams dry. I do not know whether Mr. Miller proposes to work the thin seams with shafts nine feet diameter.

Mr. MILLER—I enlarge the shafts.

Mr. LUPTON—He would enlarge the shafts so as to supply sufficient ventilation for that large underground area; everybody knows that he is capable of calculating the area of shafts required for such a mine as he suggests.

The CHAIRMAN—It appears to me to be a paper that comprises so many points that, unless we have it before us in print, it will be almost impossible to discuss it. As for instance, the thickness of the beds would be found to vary in different places. If we had information on the point it would be of great use to us. Suppose the winning is to be made, that should be gone into. Also as to the cost—who can tell what the cost will be? It will be very great indeed, depending on how the water is got rid of and the quantity also. Without that it will be simply the cost of sinking and preparing the workings for getting coal. I propose that the paper be printed and when that is done that we have a discussion on the paper.

Mr. GERRARD—Mr. Miller has touched upon a most important question with regard to a portion of this district—the water question at Barnsley. There is no doubt it will have to be dealt with some day. It has been postponed, and the load is being borne, I suppose, until it proves to be too great, and then there will be joint action to deal with it. In connection with the question of tubbing out the water in the Barnsley Seam at a depth of 226 yards, I should like to ask Mr. Miller what is the deepest tubbing that he is acquainted with? The strength of the tubbing at a depth of 226 yards is important. It is an interesting question, because we have several shafts being sunk now, dealing with large volumes of water at great pressure, which have had to be tubbed back as the work has progressed. If, out of the question raised by Mr. Miller, further papers come, and tubbing in shafts is fully dealt with, it will be a good thing. We have had papers from Mr. Embleton on means for keeping back water at moderate depths.

Mr. MILLER—The shaft is 226 yards in depth, and there is 176 yards of water in it now.

Mr. GERRARD—I beg to second the proposal that we give Mr. Miller our hearty thanks, and that the paper, after it has been submitted to the Council and approved, be printed and appear in the Transactions of the Institute.

Mr. NEVIN—One other thing occurs to me in connection with this paper—that in sinking through such water as there is in the old workings in the neighbourhood of Barnsley, any further operation would be a little bit affected by what we all hope to get some light on in the course of a month or two from the Royal Commission on Mining Royalties. I believe it is the case that the land about Barnsley is split up into many small royalties, and the place to sink pits of this kind would be dependent on finding a place where a large royalty could be got from many different owners.

Mr. MILLER—I do not think I can tell Mr. Gerrard of any great depth of tubbing I have known. I will have to get that information. I believe it has been put in about 200 yards, but I do not know.

The resolution was carried.

The SECRETARY—Mr. G. Blake Walker has forwarded a paper "On the Parker and Weston Pump for Colliery Purposes."

The CHAIRMAN—Mr. Walker cannot be with us, as he has gone to Australia, and it is suggested that his paper be taken as read, printed, and discussed at the next meeting.

Mr. SOUTHALL—I propose that we thank Mr. Walker for the trouble he has taken in preparing the paper, that it be taken as read, and printed.

Mr. NASH—I have great pleasure in seconding it.

The resolution was carried.

ON THE PARKER AND WESTON PUMP FOR COLLIERY PURPOSES.

By George Blake Walker, F.G.S., Assoc. Mem. Inst. C.E.

Among many useful direct-acting pumps which have from time to time been brought under the notice of colliery managers, I venture to think that there is none which is better worth all the attention of mining engineers than the pump which is the subject of the present paper.

When an invention is the subject of a paper before a professional body, such as the Midland Institute of Mining Engineers, it is too frequently the case that the paper is written with the object of puffing the particular invention of which it is the subject, but in the present case the writer has prepared the paper without any such object. He has been so well satisfied with the performance of these pumps over the last fifteen years that he has of late adopted them in preference to all others, and has now eighteen of them at work, from a very large to a very small size, working under a variety of different conditions, and he felt that it might be advantageous to other members of the Institute if a paper describing the action of this excellent machine were laid before them; notwithstanding that it may be well known to some of the members.

The Parker and Weston Pump is of the direct-acting class, and is made to work either simple or compound. Its general arrangement is shown in the illustrations. Taking first, one of the simple type, the writer has chosen, as suitably representing this type of pump, a 10 inch steam cylinder, fitted with the patent chest, the cylinder, for working, being coupled up by means of a middle or distance-piece, direct to a double-acting pump cylinder of ordinary design.

The patent chest may be driven either by steam or compressed air, and this type of pump is used successfully in forcing all liquids in the manipulation of which steam driven pumps are employed.

The valves which regulate the admission and release of the steam to and from the cylinder are entirely steam moved, and therefore no tappets or other mechanical contrivances liable to derangement are required, and owing to the certainty of action thus obtained the pumps may be worked at speeds varying from 1 to 200 strokes per minute.

These steam pumps are all made with long strokes in proportion to their diameter, and as they require to make fewer strokes per minute, the loss from clearance and the wear and tear of the pump valves is thereby reduced to a minimum.

Description.—The main valve of the steam chest is a hollow cylindrical iron casting fitted with a loose central D valve, and the steam is admitted to the interior through an oblong hole in the top side of the valve, in which the tumbler also moves when actuated by the hand lever.

The interior of the chest is bored truly cylindrical, and the valve turned to fit; and the valve is provided near each end with cone spring rings to prevent the passage of steam.

The auxiliary valve which regulates the admission and release of steam to and from the main valve works in a cylindrical chamber bored parallel with the main valve, and is made of steel, of small diameter, compared with the main valve.

Both valves may easily be taken out for inspection, after first removing the steam chest lids.

Action.—The working of the engine will readily be understood by a reference to the accompanying diagrams.

We will suppose that steam has been admitted through port A, Figs. 6 to 9, Plate I, and that the piston is travelling in the direction indicated by the arrow, both the main and auxiliary valves being at the right hand end of the chest. This state of things continues until the steam piston has passed a hole B^1 in the steam cylinder, when the steam that has been propelling the piston rushes up the hole B^1 which communicates by a groove C cut in the steam chest face with the circular groove E turned in the auxiliary valve; then passing through the cross passage F^1 the steam gets between the main valve and the steam chest lid, drives the valve over to the left, and allows the live steam in the chest to find its way on to the right hand end of the main piston, at the same time opening port A to exhaust at the opposite end. The piston is thus instantly stopped in its motion, and proceeds to make a stroke in the opposite direction.

The steam admitted to the main valve by the hole B^1 is also conducted through the passage N^1 to the end of the auxiliary valve, which it drives over to the left, thus rapidly cutting off the supply of steam from the main cylinder, and placing the auxiliary valve in position for admitting and exhausting steam to and from the main valve.

The steam used in moving the main valve is exhausted through the passage H, thence to the groove E in the auxiliary valve, then by small passages in the auxiliary valve which conduct it to the enlarged chamber K surrounding the valve, and finally escapes through L into the main exhaust pipe.

When it is desired to use the steam on the compound principle, the high and low pressure cylinders are placed in tandem as shown in Figs. 1 and 2, Plate I., which represents a pump having an 8 inch high pressure cylinder and 12 inch low pressure cylinder, and an 8 inch pump, calculated to force 13,000 gallons per hour about 130 feet high. This pump is intended to be an improved application of the direct-acting pumping engines, which are gradually becoming more common for all the purposes to which they may be applied. The great drawback to this class of pump, hitherto, has been their inordinate consumption of steam. This is a

fatal objection in the case of pumps of large size, for very soon the question of economy forces itself upon the notice of the user, and the consumption of fuel becomes a question which he is obliged to take into consideration. As there is no rule without exceptions, perhaps there are certain pumps to which these remarks do not so sweepingly apply, but that a perfect direct-acting pumping engine has been found, few, if any, will be prepared to admit. Efforts in this direction have, however, not been wanting, and some of the latest adventurers in this field have been Messrs. Parker and Weston, who come to the fore with what they term a "compound steam pump. Of this pump we entertain considerable hope. Whilst designed to do a fair day's work its consumption of fuel is not likely to be out of proportion thereto, and this is the combination that practical minds have long sought. A reference to Plate I. will perhaps enable the reader to follow the description of the pump which is quoted from the columns of *Engineering*.

"In these views are shown two steam cylinders, one high pressure and the other low pressure, placed one behind the other, having a piston rod common to both, which is also connected to the pump piston in the same line. Each cylinder has a steam chest and a set of valves receiving independent motion from their respective steam cylinders, but connected by a small rod to prevent any possibility of their not moving together, and having a starting handle common to both, which it will not be found necessary to use if the steam is turned on quietly, and all parts allowed to heat and free themselves from the differences of expansion. The main valve of each steam chest is a hollow cylindrical casting, and the steam is admitted to the interior by an oblong hole in the top of the valve. The interior of the steam chest is bored truly cylindrical, and the valve turned to fit. Rings are provided near the end of the valve to prevent the passage of the steam. The auxiliary valve, which regulates the admission and release of the steam to move the main valve, is usually made of steel, and is of small diameter compared with the main valve. It works in a circular chamber horizontal and parallel to the main valve. Both valves may be easily taken out and examined by removing one of the steam chest lids. The cylinder covers and distance pieces are also so arranged that, by merely unscrewing the nut at the back of the pump piston and removing the left hand cover of each steam cylinder, the pistons may be slipped out and the rings examined or replaced without disturbing the cylinders themselves.

"We will now endeavour to explain the working of the engine. The action of the steam valves will be better understood by reference to Figs. 6 to 9, which represent a steam cylinder as applied to the smaller sizes of pumps without expansion gear. We will suppose the engine to have been started and the piston to be travelling in the direction of the arrow. The main valve is at the right hand end of the steam chest, and steam is entering the left hand end of the cylinder by the port A. The auxiliary valve is also at the right hand end of the steam chest. This state of things continues until the main steam piston has passed a hole B^1 in the steam cylinder, when the steam that has been used in propelling the piston rushes up the hole B^1,

which communicates with the circular groove L^1 turned in the auxiliary valve, passes through the cross passage F^1, and getting between the main valve and the steam chest lid drives the valve over to the left, and allows the steam in the chest to find its way on to the right hand end of the main piston, and to exhaust from the opposite end. The piston is thus instantly stopped in its motion and proceeds to make a stroke in the opposite direction.

"The instant the port A^1 is charged with steam from the chest by the movement of the main valve a small hole G^1 conducts steam from the port A^1 to the end of the auxiliary valve, which is thus shot over to the opposite end of the valve chest and placed in a position for admitting and exhausting steam to and from the main valve. It will thus be seen that the main valve makes its stroke first, and on steam being admitted to the cylinder, the auxiliary valve then moves over.

"The steam used in moving the main valve is exhausted through the passage E, thence into the groove L^1 in the auxiliary valve, and finally escapes into the chamber M, and thence by the hole C into the main exhaust pipe. When the main valve has made about half its stroke it closes the outlet for the exhaust C, and the remaining steam is confined between the end of the valve and the steam chest lid, and thus effectually prevents the valve from striking the ends.

"Having thus described the working of the steam valves, we will now proceed to show how the compound working is effected.

"We will suppose the pistons to be travelling in the direction indicated by the arrow (Figs. 1 and 2). Steam is being admitted at the pipe A through the expansion valve B into the steam chest C, and along the port into the cylinder D. The steam from the other end D^1 is being exhausted along the pipe E through the steam chest F into the end of the low pressure cylinder G, the other end G^1 being in connection by the pipes each with a condenser I on the suction pipe of the pump. When the pistons have reached the end of their strokes the valves are moved as before described, giving steam to D^1, exhausting D into G^1 and G to the condenser, and thus makes the back stroke.

"The expansion valve B receives its motion from the water cylinder. A small water regulator K is placed upon the middle of the pump cylinder and communicates with the expansion valve B by means of the pipe L, which is passed down and along underneath the bed-plate.

"The water regulator will be seen in section in Fig. 3. The object of the ball valve is to allow of the free passage one way for the water when lifting the expansion valve, and admit of its back flow being throttled by the thumb screw which, when partially closed, prevents the valve from dropping too suddenly.

"Figs. 4 and 5, show the expansion valve in section more clearly. The piston M works up and down inside its cylinder, and is connected by three ways with the ring N, which covers and uncovers the steam port O, thus cutting off steam when required. The piston M is connected by a small rod with the piston P inside the cylinder Q, to the bottom of which the water is conducted by the pipe L.

"When the main pistons are in the position shown and travelling in the direction

To illustrate Mr G. Blake Wo

FIG. 1.

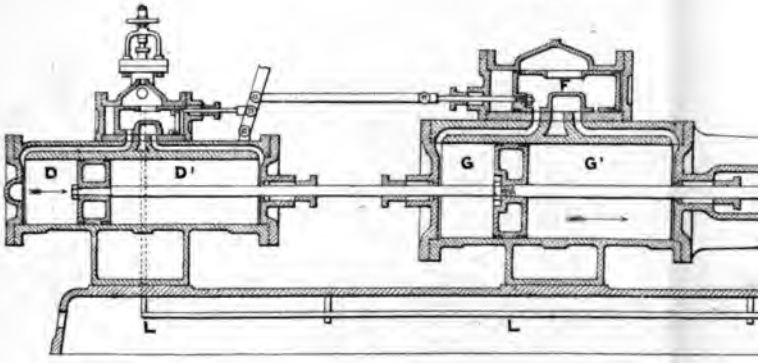


FIG. 4.

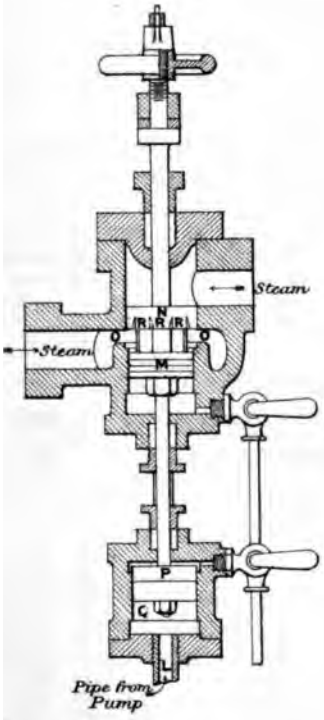
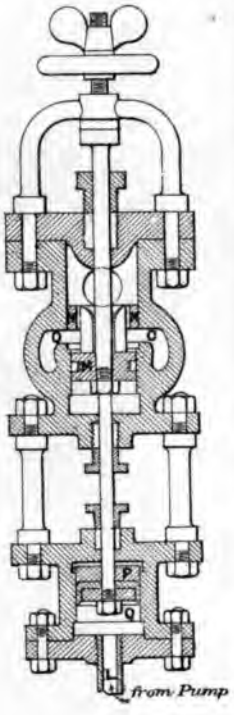


FIG. 5



of the arrow, there is enough pressure in the right-hand end of the pump cylinder to hold the expansion valve, up which it allows the steam to rush freely into the high pressure steam chest. Directly the pump piston passes the centre of the cylinder, it uncovers the hole to the water regulator and relieves the pressure from the pipe L into the left hand end of the pump cylinder, and allows the expansion valve to fall by the steam acting on the top of it, preventing any more steam from entering during the stroke. When the main pistons reach the end of the stroke they pause until the steam has had time to rush through some small file grooves R in the ring N and get the pressure behind the high pressure piston, when it starts on the return stroke, and as the pressure increases in the pump, so does the water acting under the piston, P, give steam proportionally to the work, until the pump piston again passes the middle of its cylinder, when it again cuts off steam by relieving the pressure under the expansion valve.

"This arrangement also provides a very perfect governor, and prevents any damage to the pumping engine through the failure of the suction valves in closing, as without this provision should such a thing happen the main piston having full steam would rush along and strike the cylinder covers. This arrangement is found to effectually prevent this."

As stated in the early part of this paper, I have now eighteen of these pumps at work, the largest having a steam cylinder of 25 inches and double-acting ram 8¼ inches diameter, the stroke being 3 feet. This pump is pumping water from a depth of 95 yards to the surface, and has worked perfectly satisfactorily for a number of years. The pumps are made of two types, ordinary piston pumps and ram pumps. They are made with steam cylinders from 4 inches to 25 inches and upwards.

The following table gives a few representative sizes, showing the proportion of the steam and water cylinders, and the quantity of water pumped, and the column against which can be forced with a pressure of 40 lbs. of steam:—

Diameter of cylinder in inches...	5	7	8	10	14	20	25
„ of water cylinder „ ...	2½	3	4	6	6	7	8¼
Length of stroke in inches ...	12	12	12	24	24	36	36
Gallons per hour	1,200	1,760	3,200	7,250	7,250	9,600	12,550
Height forced in ft. (40 lbs. steam)	230	320	233	163	320	480	536

The result of my experience with these pumps is, that they give no trouble in working, are not liable to excessive wear or derangement, will start themselves after being stopped through a failure of steam or air, and can be left to work without constant supervision.

DISCUSSION ON MR. JOHN NEVIN'S PAPER "ON THE DIFFERENCE BETWEEN THE SEAMS IN THE NORTHERN AND SOUTHERN PARTS OF THE YORKSHIRE COALFIELD, AS SHOWN IN SOME OF THE DEEPER SINKINGS."

The CHAIRMAN—Mr. Nevin favoured us with a paper "On the Difference between the Seams in the Northern and Southern Parts of the Yorkshire Coal-field as shown in some of the Deeper Sinkings." Has he any further information?

Mr. NEVIN—I do not know that I have anything further. I had hoped that somebody in the Barnsley district, or rather west of Barnsley, who was interested in the lower seams there, such as the Ganister Beds at Oughtibridge, and other seams, would have been able to give us sections below the Whinmoor down to the the Millstone Grit. So far I have not heard from anybody; but if anybody could give us that section I think it would add interest to the paper. We have the section for the north, but I am not aware of any section below the Whinmoor Coal in the southern part of the Yorkshire coal-field.

The CHAIRMAN—I think we must postpone the discussion on Mr. Snell's paper on "The Distribution of Electrical Energy over Extended Areas in Mines," and Mr. Russell's paper on "The Geology of the Southern Portion of the Yorkshire Coal-field," as the authors are not present to give information or answer questions.

PAPERS READ BEFORE OTHER FEDERATED INSTITUTES.

The SECRETARY—I have put on the agenda paper a number of papers read before the other Federated Institutes for discussion, and I should be glad if any member who has read them would open a discussion or send me notice that he would like to do so at the next meeting.

Mr. LUPTON—Do you not propose to put papers down for discussion unless you do get such notice?

The SECRETARY—That will be better than putting a great many down so that nobody knows which will be dealt with. I thought after to-day of only putting down those of which I have special notice, hitherto I have put all down.

The CHAIRMAN—Unless we do that they are all passed over. It is a good plan to have notice.

The SECRETARY—We have received Part III. of the Federated Transactions. By next meeting we shall have Part IV., and I shall put all the papers which appear in that part on the agenda paper, but none of those in the earlier parts unless some member gives notice that he wants to discuss them.

Mr. GERRARD—It appears to me that if a paper contributed by a member of another institute was discussed here the author would see the points raised and might reply in his own institute. Any question put at our own Institute meeting might be considered by the author at the meeting of his institute, which if it were not so would be passed by or require the presence of the questioner at the Federation meeting. If we could establish such a line as that it would increase the interest of our meeting.

Mr. LUPTON—Suppose a paper is read in one place, and a criticism is made upon it at another, that criticism cannot be replied to as if the author were present. But if that criticism is sent to the author by correspondence he can reply to that criticism as well as to the criticisms made in his presence. Just as in the Institution of Civil Engineers the reply is made not only on the discussion but on the correspondence. It seems to me that unless we bring the postman into requisition we shall be behind in our system of discussing papers in these mining institutes.

The SECRETARY—The object of the Federation was that all that trouble should be saved, that the opinions of the various institutes on a paper read in any institute could be ventilated just as if the paper had been read at that particular institute, that a paper read at the North of England Institute could be discussed and thrashed out by the Midland Institute, and the opinions of the Midland Institute would be taken up by the author at the next North of England meeting, and he would give his answer there.

Mr. LUPTON—The answer at Newcastle should be directed to the criticisms at Newcastle, and the answer at Leeds to the criticisms at Leeds, and then both are answered.

The SECRETARY—It was understood that the author should answer all criticisms at his own place.

Mr. GARFORTH—May I suggest that this question of what is intended should be brought forward at the next meeting of the Federated Institutes. My idea has been that papers read at this Institute may be discussed equally at other institutes, Chesterfield, Newcastle, or South Staffordshire.

Mr. LUPTON—But if he has only to reply at his own institute, how is he to reply to other criticisms?

Mr. GERRARD—That is the point, the reply would be too late.

Mr. LUPTON—A year too late. If he has a copy of the discussion sent to him as author of the paper, then he has a chance of replying to that institute, and every argument is answered. It is fair to the reader of the paper.

The CHAIRMAN—I think the question will be settled at the meeting at Newcastle.

Mr. GARFORTH—May I ask the Secretary to make a note to bring the matter forward?

The SECRETARY—I will take it as an instruction that I am to ask the Secretary of the Federated Institutes about this.

Mr LUPTON—Yes, I think the discussions should be sent to the author, so that the reply may appear with the criticisms.

Mr. PEARCE—Mr. Lupton has mentioned the way that the Institution of Civil Engineers conduct their discussions by correspondence, and many engineers are thus able to write on subjects that they are specially acquainted with, but who cannot attend the meetings. I should like to see the same thing adopted by the Federated Institutes. I have been a member of the North of England Institute for thirty-four or thirty-five years, but have never attended a meeting at Newcastle. If the matter was conducted by correspondence I could then take part in some of the matters that come before the institute if I wished to do so.

The CHAIRMAN—I shall lay these matters before Professor Lebour, and I hope that in January he may be in a position to set a great many of these matters right.

Mr. GARFORTH moved a vote of thanks to the Chairman.

Mr. PEARCE seconded the motion.

Mr. GERRARD put the motion, which was carried unanimously.

The CHAIRMAN acknowledged the compliment, and the meeting ended.

SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

GENERAL MEETING, OCTOBER 2ND, 1890.

MR. HENRY LEA, PRESIDENT, IN THE CHAIR.

The business was purely formal, and instead of the ordinary reading of a paper or papers, the members proceeded by special car to the Birmingham Central Tramways Electrical Charging Station at Bournbrook, which they inspected, through the influence of the President and the kind permission of Mr. Joseph Smith, the chairman of the company. Mr. Lea, who is consulting engineer to the Corporation, personally conducted the members through the admirably-equipped station, which is one of the best, if not actually the best, of its sort in the United Kingdom. What was actually on view may be briefly stated, commencing with the initiation of the whole process. Two multitubular boilers, working at 120 lbs. per square inch, were first inspected, then the purifier for removing both carbonates and sulphates from the feed water, and next two compound non-condensing engines by Davey and Paxman, each equal to about 100 horse-power. Attention was then drawn to the two Elwell Parker dynamos, equal to about 60,000 watts, and switch-boards of most modern construction. The greatest amount of interest was perhaps displayed in the special elevator cages for receiving storage batteries from the cars, and the process of re-charging the batteries and returning them, the hydraulic machinery for actuating the elevators and the motors, and brake arrangements for the cars. The whole station, both for the manner in which it has been built and fitted, certainly deserves every whit the encomiums passed upon it. The members returned to town by the car in which they had journeyed outwards, and had tea together at the Colonnade Hotel.

SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

GENERAL MEETING, DECEMBER 11TH, 1890.

MR. HENRY LEA, PRESIDENT, IN THE CHAIR.

The minutes were read and confirmed, and after the formal business had concluded the members were conducted by Mr. Henry Lea to the front of the Great Western Hotel, from whence they proceeded by tram to the Birmingham Central Tramway's Cable Depôt, Hockley, which they inspected, through the influence of the President and kind permission of Mr. Joseph Smith, the chairman of the company.

Mr. Alfred Dickenson, the engineer to the company, pointed out the following specialities :—

Lancashire boilers, working at 80 lbs. per square inch.

Two pairs of Tangye engines, with Jeffries' automatic expansion gear.

Two sets of geared cable pulleys, driving cables, running at 7 miles an hour and 8 miles an hour respectively.

Guide pulleys underneath the street.

Automatic tell-tale for indicating if a wire of the cable break while at work.

Feed-water heater and other accessories.

Cars in running shed and grip action belonging thereto.

After the inspection, the party returned by tram and had tea together at the Colonnade Hotel.

FEDERATED INSTITUTION OF MINING ENGINEERS.

GENERAL MEETING,

HELD IN UNIVERSITY COLLEGE, NOTTINGHAM, ON WEDNESDAY, SEPTEMBER 24TH, 1890.

MR. JOHN JACKSON, J.P., VICE-PRESIDENT, IN THE CHAIR.

The CHAIRMAN said he had been asked by the Council of the Federated Institution to preside that day in the unavoidable absence of their President, Mr. John Marley, who, owing to a protracted illness, was unable to take any active part in their proceedings. He was sure they all regretted the cause which kept him away, and hoped he would soon recover sufficiently to come again amongst them to take part in those objects for which they had federated themselves together. This was the fourth meeting of the new Institution, and it was very gratifying to know that their numbers had increased, and that the results of publishing the Proceedings of all the different institutions in one volume had been to promote their prosperity. There was a great deal on the agenda paper, and he did not propose to make any sort of an address. He proposed that the papers on the agenda should be read first, and then, if there was time, to enter into discussion on others that had been read previously.

Mr. GEORGE LEWIS, being called upon by the Chairman, read the following paper, entitled "A Geological Sketch of the Town and District of Nottingham":—

A GEOLOGICAL SKETCH OF THE TOWN AND DISTRICT OF NOTTINGHAM.

By George Lewis, M. Inst. C.E., F.G.S.

The writer does not wish this to be considered an exhaustive paper, and indeed for such a purpose the time given for its preparation would not admit of such a one being written. In anticipation of the meeting of the Federated Institution of Mining Engineers in Nottingham for the first time, the Council of the local Institute had intimated their desire that a short geological sketch of the district should be prepared, with some description of the various mining operations, for the assistance of those who might come from a distance. Having this limited object in view, the paper only deals with the area over which the various routes of the proposed excursions will pass to-morrow, and therefore must of necessity be of a partial description.

The town of Nottingham dates from very ancient times, and an ordinary observer cannot but be impressed with the beauty and adaptability of its site, with the River Trent flowing peacefully in the distance. The old town is principally situated upon a rising eminence; the castle having been erected upon a noble rock on its southern side, rising vertically to a height of upwards of 200 feet from the River Leen below. From this point a magnificent view of the surrounding country may be obtained, showing the River Trent rolling along within view, and presenting a scene not easily to be forgotten, and requiring a more fertile imagination than the writer's to describe.

The castle has undoubtedly been a stronghold for many generations, the dwellings in the rocks clearly pointing to this; but its history is not intended to be here dwelt upon. The attention of our members may, however, be directed to the costly collections of art treasures it contains, leaving them to moralise upon the change of scene as now depicted there, and the time when the site was occupied either by the barbaric forces of remote times, the stately warriors of the Middle Ages, or as the palatial residence of the Dukes of Newcastle.

The town is built upon the New Red Sandstone formation, which sets in, with the general dip of the strata upon its western side, towards the east, and extends northwards to the limit of the county. The dip of the strata is a gradual one, varying from 1 in 7 to 1 in 14, and being, at the extreme point to the east, at which it has been proved, not more than 1 in 30.

The routes of the different excursions, as arranged for to-morrow, include that portion of the Nottinghamshire coal-field known as the Leen Valley, and which is intersected by the Nottingham and Mansfield Branch of the Midland Railway. With the dipping of the strata towards this valley, the newer formations of the Magnesian Limestone and New Red Sandstone gradually set in: the Coal-measures being covered, and their continuance eastwards is proved by the colliery workings already for a considerable distance carried beneath them (Plate II.).

The New Red formation in this district contains large quantities of water, the town of Nottingham being supplied from it. The Corporation have four pumping-stations; and one of them at Bestwood will, by the kind permission of the authorities, be visited by our members during their excursions to-morrow.

It will be observed from the section (Plate III.) that the Coal-measures when passing under the New Red Sandstone formation are proved to be nearly 3,000 feet in thickness, and in the valley in question may probably be more. Some years ago it was thought by many scientific gentlemen that the Coal-measures would only continue for a very short distance under these circumstances, but this theory has been for some time pretty well upset. The writer is of opinion that so far nothing has been proved as to the existence of a geological disturbance of sufficient importance to lead to the supposition that 1,000 yards of Carboniferous strata have come to an abrupt termination. It is possible that the coal-bearing strata may have become reduced in thickness, and thus the area under which coal would in all probability be found be decreased. The latter may be the case, but, if so, the distance to the east will, it is reasonable to expect, be very considerable, and the limit difficult to determine. In the neighbouring county of Lincoln, where the ironstone of the Oolitic formation is worked, it is well-known the strata still continue to dip in the same direction, and the ironstone which is now only worked there at the surface would be found further east at a considerable depth. This refers more particularly to that worked near the city of Lincoln; the noble cathedral having probably for its foundation a bed of ironstone belonging to this series. Isolated portions may certainly be found not carrying out fully this idea, but looked at broadly the dip will be found as stated. With this fact before us there appears to be no reason why productive Coal-measures should not be found at that distance from the Leen Valley, unless, which is very unlikely, they have been denuded, and the surface overlaid with a newer formation.

Under the town of Nottingham the whole thickness of the Coal-measures, as shown on the section (Plate III.), undoubtedly extends, and if some enterprising speculator were to obtain permission from the municipal authorities to sink a colliery in their market place (for which there is ample room) he would find the Top Hard Seam of coal at a depth probably not exceeding 350 yards. To the south of the town the Coal-measures also extend, the lower seams of coal being worked at the Clifton Colliery, and in this direction there seems no reason why coal should not be found for some distance: in fact, until either a geological disturbance or a gradual thinning terminates them. At Edwalton, about three miles to the south, a boring is now being put down to test the question, with the object, it is assumed, not so much of making it quite clear that coal exists there, as to test its depth from the surface, and the thickness of the water-bearing strata.

There appears no proof against the existence in the county of Nottingham of a very large undeveloped coal-field, which, for generations to come, will be quite equal to keeping up the supplies. It has, during the last twenty years, been largely developed, and the quantity raised is still increasing; but with all this, the writer

is inclined to think, little more than the fringe of the supplies has been touched. In the year 1861 there was only one colliery (the Babbington) in the Leen Valley. The output now is quite 3,000,000 tons per annum. This large quantity will, in the writer's opinion, continue to increase, and the coal-field be further developed, as the times require it, or as the smaller collieries at the outcrop of the mines in Derbyshire and West Nottinghamshire become exhausted.

The district of the Leen Valley is very free from faults, there being few of any importance, and these small ones, running north and south along the valley. Upon the plan (Plate II.) are marked those that come within the writer's own knowledge, and there may possibly be others, but of little importance. There will also probably be an upthrow fault found on the south side of the town bringing the Top Hard Seam near the surface at the Clifton Colliery. The immunity of the district from dislocations and the light dip, it need scarcely be pointed out, have materially assisted in the development of the endless rope system of underground haulage that generally prevails.

The section (Plate III.) shows the thickness of the strata and the various seams of coal in the Leen Valley district, at a point where the Carboniferous strata are covered by a thin layer of Magnesian Limestone and New Red Sandstone. The seams of coal that have been worked in the district are as follows:—The Top Hard, the Bottom Soft, the Bottom Hard, the Piper, the Furnace, the Black Shale, and the Kilburn, but there are many other thinner ones which will, in all probability, be worked in the future. The whole of the seams particularised are being mined, more or less, either in Nottinghamshire or in the neighbouring county of Derby.

The Top Hard is a very valuable steam and iron-making coal, and corresponds with the Barnsley thick coal of South Yorkshire. It is very extensively used by the railway companies, who take large quantities for their locomotives; and the blast furnaces of Derbyshire, Nottinghamshire, and Northamptonshire are principally supplied from it.

The Bottom Hard and Soft Seams are good coal, the latter used generally for domestic purposes, being both a steam and household coal. Very large quantities of these seams are being worked, and a considerable portion sent to London and the South.

The Black Shale is also a valuable seam, and extensively worked for gas-making and domestic purposes. The principal gasworks in the Midland counties are supplied from this seam, raised largely in the north of the county. It is known as the Silkstone Seam of South Yorkshire, but appears to deteriorate in quality between the north and south of this county. It is extensively worked at the Clay Cross and Grassmoor Collieries, where it is found to be of excellent quality, a very considerable portion of the output from that district being sent to London for household consumption, where its quality commands a high price.

The neighbouring county of Derby and the western side of Nottinghamshire contain large deposits of ironstone. The development of the ironstone deposits of Leicestershire, Lincolnshire, and Northamptonshire has been very considerable, and the former mines, owing to their greater cost of production, although

yielding an excellent quality of iron, have almost ceased to be worked. There is still some ironstone mined in conjunction with contiguous coal seams, and this being used in the local blast-furnaces materially improves the quality of the iron.

Plate II. is intended to give a sketch more particularly of the immediate district over which generally the excursions are proposed to be taken. Clifton—the first colliery on the list, lies about a mile south-west of the town of Nottingham. The Top Hard was here found about 60 yards from the surface, and is unworkable, the shafts being taken down to the Bottom Hard and Soft Coal Seams, which were reached at a depth of about 250 yards. The New Red Sandstone measures here are thin, and in all probability thicken towards the south. The district beyond is now being proved by a boring which is being put down at Edwalton for the purpose of testing the strata of the district, as marked upon the plan.

Three miles to the west of the town of Nottingham is Wollaton Colliery, where also the Bottom Hard and Soft coals are being extensively worked. The Top Hard coal crops out here, the seams they are working being found at a depth of 186 and 200 yards respectively. Water-bearing strata were passed through to a depth of about 80 yards, and the shafts down to that point are lined with metal tubbing.

All the collieries of the district, without any exception, during the process of sinking pass through heavily-watered strata for a distance of from 70 to 100 yards.

To the north-east of Wollaton are the Babbington Collieries, where the Top Hard coal, also the Bottom Hard and Soft, are being worked. These collieries, consisting of the Cinderhill and Newcastle Pits, were sunk about the year 1850, and were at that time the only collieries near the town of Nottingham.

To the north of these are the Bestwood, Hucknall, Linby, Newstead, and Annesley Collieries, each of them working the Top Hard Seam; this coal having been developed to an extraordinary degree during the last twenty years.

The writer cannot allow this opportunity to pass without drawing the attention of the members of the Institution to the exceedingly fine colliery plants in the Leen Valley. The shafts generally are not less than 12 feet, and principally 14 feet in diameter, fitted, as a rule, with rope conductors, although others are in use. The winding engines are of both the horizontal and vertical type, the former, however, prevailing; with coupled cylinders, ranging from 20 to 40 inches diameter. The surface arrangements for sorting and screening the coal vary according to the requirements of the colliery, and sorting belts, with various methods of screening, may be seen and noted with advantage.

The underground haulage, which at some of these collieries is carried to a distance of 3 miles from the shafts, is principally, if not entirely, on the endless rope system. The power will be found at some of them applied from the surface, whilst at others compressed air or steam is taken down the shafts and supplied to the engines which are fixed underground. Owing to the system which prevails in the district of loading the pit tubs very high, it was found necessary to run them slowly underground. The endless rope is peculiarly adapted, both as regards speed and inclination of the seams, and the various applications of the system will well repay any little time members can spare for carefully looking into the details

The ventilation is principally mechanical, and members will have an opportunity of studying the relative merits of both the Guibal and Waddle type of fans, of which examples are in work up to 44 feet diameter.

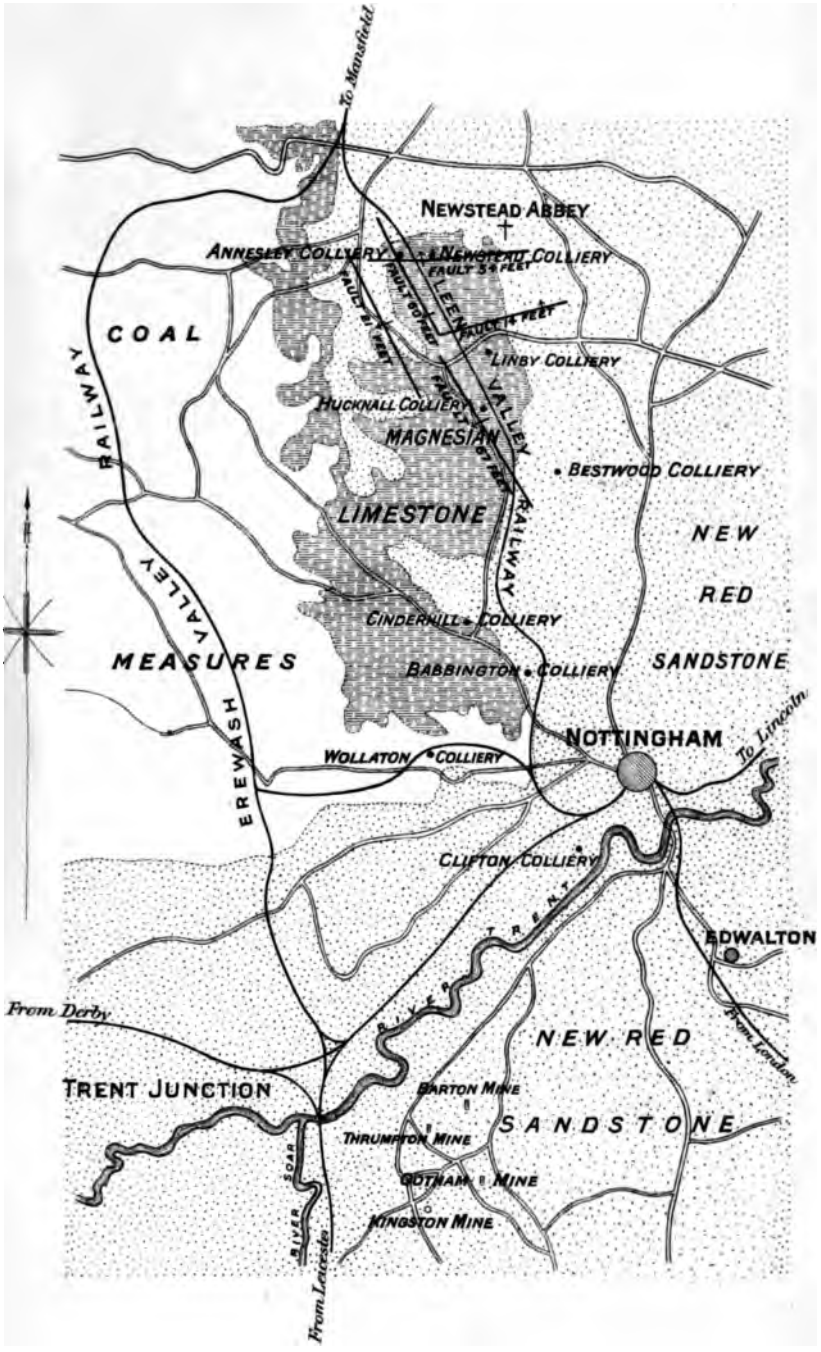
The mines are chiefly lighted by safety-lamps, and although they are not what could be termed fiery mines in the ordinary acceptation of the term, still they give off sufficient gas to make them require an exceedingly good current of ventilation to keep them clear, and, where open lights are used, very strict supervision.

The only system upon which these mines are worked is the "true" longwall, and this word is used to distinguish the method of the district from that followed in some others, but which the writer does not consider as the pure and simple longwall known here. It is not unusual to have a continuous face of over 1,000 yards in length without a "cutting" or "break" in the whole distance. The stalls themselves vary from 30 to 60 yards in length, according to the circumstances of the mine and roof. It is claimed for this system that it can be ventilated more efficiently and that larger volumes of air can be distributed at the working face than any other system can supply. Not only do the workmen at the face enjoy an atmosphere necessary to sustain them during their employment, but also, which is equally important, a current of air of greater magnitude than any other system admits, is conducted to the point from which the bulk of the gas is given off. A less percentage of small coal is also made; and in the Midland district, where size represents quality, it is exceedingly important that those having charge should be able to make the best of the seam in this respect.

In prehistoric ages the water flowing through the valley of the River Trent denuded to some extent the upper strata, thus forming a level tract of country from 1 to 1¼ miles in width, over which, to a depth of from 20 to 50 feet, *débris* have been deposited, consisting of sand and gravel. The formation on the south side of the river appears to have been undisturbed, and the edge of this valley rises abruptly from and following its course. It continues till a junction of the Trent is formed with the Soar, as shown at the south-western corner of the sketch map. These hills, or more correctly rising grounds, contain very valuable deposits of gypsum, which is extensively mined and also manufactured in the district. These mines, as shown on Plate II., belong to Lord Howe, at Gotham; to the Right Hon. Lord Belper, at Kingston; to Lady Byron, at Thrumpton; and to the Ecclesiastical Commissioners, at Barton. They are, with the exception of Lord Belper's (which is worked from a vertical shaft, about 40 yards deep), entered by means of tunnels driven from the lower side of the hills. The quantity raised in this district is from 75,000 to 100,000 tons per annum, the greater portion of which is ground in its raw state to a very fine powder, the other portion being calcined and afterwards known in the market as plaster of Paris and various descriptions of cement. Gypsum is very extensively found in the Permian formation of this district, and is also being worked to the south-east of Nottingham, and at Weston and Chellaston to the east. The gypsum of the district is said to be more suitable and valuable for various purposes than any other found in this country; and although there are large deposits in Staffordshire, Cumberland, and Sussex, the Trent gypsum commands the highest price in the market.

To illustrate Mr George Lewis's paper on "A Geological Sketch of the Town & District of Nottingham."

THE NOTTINGHAM COALFIELD.



SCALE, 3 MILES TO AN INCH.

ANDREW REID SONS & CO. LTD. NEWCASTLE

To illustrate Mr. George Lewis's paper on "A Geological Sketch of the Town & District of Nottingham."

THE NOTTINGHAM COALFIELD.

SECTION OF STRATA.

SCALE 80 YARDS TO INCH.

STRATA	THICKNESS Yds.	Ft.	In.	DEPTH Yds.	Ft.	In.
NEW RED SANDSTONE	12	0	0	12	0	0
MAGNESIAN LIMESTONE	6	0	0	18	0	0
COAL	1	1	0	229	1	0
TOP HARD COAL	1	1	0	473	0	1

STRATA	THICKNESS Yds.	Ft.	In.	DEPTH Yds.	Ft.	In.
WATERLOO COAL	1	3		519	2	1
COAL		2	8	537	0	3
BROWN RAKE IRONSTONE	1	1	3	620	0	0
BLADY RAKE IRONSTONE	1	0	8	630	0	0
BOTTOM SOFT COAL	1	0	0	657	2	0
BOTTOM HARD COAL	1	1	10	671	2	1
PIPER COAL	1	1	8	687	0	3
FURNACE COAL	1	0	5	724	2	0
BLACKSHALE COAL	1	2	11	778	0	0
KILBURN COAL	1	0	2	922	1	2
COAL			10	1084	1	10

ANDREW REID BOND & COLTHAM NEWCASTLE

The question of the causes which have led to its formation is far too complicated to be thoroughly treated in a short paper of this description; but it certainly appears an interesting subject. In the writer's opinion, various causes have led to the formation of these deposits; but those immediately in question have, he believes, been deposited in inland lakes, the waters of which have been evaporated. Whatever the cause may have been, they find a useful place in the manufactures of this country, and point to another instance of a wise provision that nature has formed and stored up in the crust of the earth for the uses of man.

The CHAIRMAN—I am sure Mr. Lewis will be willing to respond to any question any member would like to ask him, although the paper is more of a descriptive than of a controversial character.

Mr. W. BEATTIE-SCOTT (H.M. Inspector of Mines, Birmingham) asked Mr. Lewis if it was to be understood that the water-bearing strata he spoke of in Nottingham extend only to the Magnesian Limestone, or that they descend into the lower geological horizon? If the former, do they take the form so well known in the north as "quicksand formation?"

Mr. G. LEWIS—We find on sinking, in the upper strata and the limestone also, large quantities of water, but very little water after reaching the Coal-measures. So far as I am aware, quicksand has not been found at any sinkings in this district. We always find sand, but it is pretty strong and being very porous holds a large quantity of water. It is full of crevices.

No one else asking any questions, the CHAIRMAN said he was sure they were very much obliged to Mr. Lewis for his paper. Those who were going with the excursions on the morrow would now be able to enjoy themselves much better than they otherwise would have done if the route had not been explained.

Mr. G. LEWIS expressed his acknowledgments.

Mr. M. H. MILLS read his paper, "A few Notes on the Ironstone Deposits of Leicestershire," as follows:—

A FEW NOTES ON THE IRONSTONE DEPOSITS OF LEICESTERSHIRE.

By M. H. Mills, F.G.S.

It is not the writer's intention at present to attempt more than a few notes on the geology of the district occupied by the ironstone deposits in Leicestershire; but he hopes on a future occasion to lay a more exhaustive description before the Institution.

It was not until about 1838 that the ironmasters of the North of England were induced to try other than the Coal-measures ironstones, and several members of our Federated Institution—Sir Lowthian Bell, Mr. Jos. Bewick, Mr. John Marley, and others—had a hard fight to induce the engineers of those days to use the iron made from the Marlstone beds of Yorkshire; but after careful scientific research, and able manipulation in the furnace, aided by the low price of production, all prejudices were overcome. The ironmasters of the Midland Counties appear, however, to have been somewhat tardy in recognizing the value of the extensive deposits of ironstone in the county of Leicester, as it was not until about 1876 that any determined attempt was made to work the stone.

Passing now to a consideration of the geological position of the workable beds of ironstone, the Government geological map of the district shows that the extensive tract of country called the Vale of Belvoir is formed of the soft Keuper sands and heavy overlying Lias shales, with thin beds of limestone, as worked at Barnstone. All these beds appear to lie conformable one to the other, with a slight dip to the south-east, which, it must be remembered, is no guide to the dip of the underlying Coal-measures, it being well known that many ages elapsed between the Coal-measure period and the deposition of the Permian beds; it is therefore only by boring or actually proving the position of the Coal-measures under the Lias, that any valuable information can be obtained. It is however, encouraging to know that so far no proof has appeared that the Coal-measures alter their usual dip by rising or thinning away to the east; and there is, to the writer's mind, every prospect of the town of Nottingham becoming the centre of the coal and iron industries of the Midland Counties.

Further eastward will be seen a well-defined escarpment of hard arenaceous beds, and these are what geologists call the Marlstone; the workable bed of ironstone, which is from 6 to 9 feet thick, lying on the summit of this escarpment, and with the overlying Oolitic limestone forming an extensive table-land. The area of valuable ironstone is unfortunately most variable, and does not lie like a seam of coal, almost uniform in thickness and quality; the bed often thinning out and becoming practically valueless, and thus causing great disappointment, to those expending capital in working the stone. Mr. E. Wilson, curator of the Bristol Museum, wrote a very interesting paper on "The Lias Marlstones of Leicestershire," for the Midland Naturalists' Society. The writer does not feel as certain as Mr. Wilson appears to be, that all the workable beds of Leicestershire ironstones are in the Marlstone, as

appearances are rather in favour of, at any rate, some of the deposits being in the Lower Oolite. He has never heard that the characteristic fossil of the Marlstone rocks has been found associated with the Leicestershire ironstone, though he understands that *Belemnites elongatus*, etc., have been found in somewhat similar beds in Rutlandshire. Near the point marked A on the map exhibited, there is a well showing the Oolitic limestone lying immediately upon the ironstone bed, and below this bed of ironstone are arenaceous limestones of distinctly Oolitic character.

It is quite possible, and even probable, that the distinctive fossils of the Marlstone beds may eventually be found, and this would settle the point and show that a less denudation of the Lias beds has taken place, than the writer at present suggests.

In a future paper on this subject, the writer hopes to go more fully into the correlation of the Marlstones of Cleveland and the beds of the eastern counties.

In his paper referred to, Mr. Wilson says:—"The Marlstone Rock or Rock bed is a hard, ferruginous, earthy, and highly fossiliferous limestone, passing into an ironstone, *which lies in the midst of the softer shales of the Lias formation.* It constitutes the upper member of the Middle Lias series, the lower member comprising a series of sandy shales which graduate into the underlying clays of the Lower Lias." Now, in Leicestershire, the writer does not find any Lias shales above the ironstone bed. Mr. Wilson's description of the outcrop of the Marlstone beds in Leicestershire is as follows:—"To the north of Melton Mowbray the Marlstone constitutes a considerable outline at Holwell. The ordinary ferruginous stone alternates with brashy shell beds or jacks, and a few local blue-hearted encrinital bands. The ironstone is here well jointed, a feature which facilitates its extraction. The lower arenaceous and unproductive beds appear in a railway cutting in one of the quarries faulted against the ferruginous bed. From Holwell the Marlstone extends westward by Wartnaby to Greenhill, near Old Dalby. At Wartnaby it is worked close to the edge of the escarpment, by the Stanton Iron Company. From Greenhill the Marlstone extends eastward in a fine line of escarpment to the railway tunnel at Long Clawson. At this point the rock bed and underlying Lias shales have been broken through, and their place occupied by boulder clay to a depth of nearly 100 feet. From Long Clawson the Marlstone Rock bends round to the north-east along the well-wooded heights of Belvoir Hills to Belvoir Castle. To the south of Belvoir the Marlstone Rock is exposed in the quarries of Woolsthorpe, Knipton, and Branston, and in all of these the junction of the ferruginous and arenaceous beds is very sharply defined. From Woolsthorpe, the Marlstone Rock extends by Denton and Harloxton in Leicestershire to Grantham, and by Barrowby and Great Gonerby, to Caythorpe and Welbourne in Lincolnshire. The escarpment due to this rock falls all the way from Woolsthorpe, coincidently with the dip of the beds, coupled with a certain amount of attenuation."

It will thus be seen that there is an almost continuous outcrop of this Rock bed from Melton Mowbray to a little west of Grantham, and all along this outcrop there are extensive workings in the ironstone by the Holwell Iron Co. and the Stanton Coal and Iron Co. at Holwell and Wartnaby; by the Eastwell Iron Co. at Eastwell; and by the Eaton Iron Co. and Holwell Co. at Eaton, near to Belvoir Castle: and north of Belvoir Castle by the Stanton Co. at Woolsthorpe.

There is little if anything to describe in the method of working the stone. The cover is not more than from 4 to 6 feet thick; the workable ironstone averaging about 8 feet, and under this a few feet of ferruginous limestone passing into more arenaceous limestone. Long cuttings are driven in the workable stone and a line of tramway is kept close up to the face of the workings so opened out; the stone being removed in small iron wagons by locomotive power to a tippler, where the stone is loaded into the railway wagons. All refuse stone is spread evenly immediately behind the working face, and the soil placed on the new surface, leaving the land in nearly as good condition, as before the removal of the ironstone. It is not usual to calcine this stone, though in some cases, where the stone is heavily charged with moisture it is found advisable to do so.

The probable extent of the workable ironstone in Leicestershire is difficult to estimate, as much depends on the value of the beds passing under the newer formations; and until this is proved any calculation would be utterly valueless. Still the writer is strongly of opinion, that a considerably larger area than is at present known will be proved in the future, and with the close proximity to the coal it may be safely assumed that Leicestershire will become one of the great iron-producing counties of England.

The writer does not propose to carry this subject further at present, and hopes these few notes may prove interesting to those visiting Belvoir to-morrow. On a future occasion he hopes to give sections and analyses of the Leicestershire ironstones as compared with those of Northampton and Cleveland.

The CHAIRMAN having asked if any member had any questions to put to Mr. Mills, and receiving no reply, thanked Mr. Mills for the trouble he had taken in preparing that paper. As it was stated to be only a preliminary paper, they might anticipate at a future time an exhaustive one on the ironstone fields of Leicestershire.

The CHAIRMAN said that Mr. Hargrave Walters had written a paper entitled "An Experience with Explosives used Underground," and he (the Chairman) asked that the paper be taken as read. Discussion could then be raised upon it on a future occasion.

AN EXPERIENCE WITH EXPLOSIVES USED UNDERGROUND.

By Hargrave Walters, Bibley Collieries.

It is well known, to all members of the Federated Institution in particular, that great efforts have been made for a number of years past to ensure safety of life in coal mines, but never more, probably, than at the present time. Papers on any subject whatever that lead in this direction, however little, may be considered as worthy of attention; and it is with such a view that this paper is presented.

The writer's association with the Chesterfield Institute dates from its commencement; and he well remembers that one of the earlier discussions was on a valuable paper on fans, by Mr. Robert Howe. Many experiments were made, and much useful information resulted. The next thing of importance was, he believes, coal-dust experiments, which threw a great deal of light on that subject. Then came a most exhaustive paper by Mr. A. H. Stokes (H.M. Inspector of Mines) upon the report of the Royal Commission on Accidents in Mines, which led to interesting and useful discussion and experiments with safety-lamps. But for the moment the writer has no recollection of a paper on the subject of explosives, or of any of the mining institutions having taken up thoroughly, or made specific trials with the various kinds of explosives now generally in use underground.

In dealing with this question, it is not intended to enter into any competitive merits of the several explosives which may have to be named, beyond simply giving a slight history or account of an experience with them of nearly eight years in a Silkstone mine, not altogether classed as fiery, still with rising faces very troublesome by the presence of gas at every slight disturbance or break in the goaves and other working places. Under these circumstances, together with a dusty mine, the safe use of gunpowder was excluded, and it became necessary to adopt wedging in the greater part of the pit and at one time in the whole of it.

In the latter part of the year 1886, an instance occurred which proved the wisdom of this course. At that time much was being done to render the use of lamps safer. Agreeing with the general idea that some improvement at least was necessary, we had just added an extra gauze and bonnet to our lamps, when a strong blower of gas broke from the floor in one of the gates in a most unlikely place, extinguishing the whole of the lamps through the benks over which the gas had to pass, and as the current there was very strong we could not help feeling that we had in all probability benefited by the step we had taken. This occurrence only increased the difficulty of using powder; and as getting the coal by any other means than blasting was both expensive and produced more slack it became necessary to try some other means of meeting the position. The writer turned his attention to other classes of explosives, but before using any of these to a great extent was at considerable pains in testing and observing their action and behaviour in the pit. None of these satisfied him altogether, including the use of the water cartridge, as he had observed a little flame in each case. To further test these things he spent considerable time in experimenting on the surface, both in daylight and darkness. He first tried the effect of firing half a pound or so of powder in about a sack of coal-dust. This dust being very favourable for such a test, a flame something

dreadful to contemplate as happening in a dusty pit, in the case of a blown-out shot, was sent up.

He then tried nitro-glycerine and similar compounds, but failed in any degree to ignite the dust. This was very satisfactory, and a great relief, as he had also observed, in testing for blown-out shots underground, that what little flame there was seemed to stick to the face of the coal. Under such conditions, the working places being carefully examined before firing, and found free from gas, it would seem safe to employ the last-named explosives.

Notwithstanding this, he still found other sources of danger, similar to what had been many times met with when using powder. On one occasion, he believes it was when using tonite fired by battery, on the deputy examining the place *after firing*, he observed several jets of gas burning from the face among the fallen coals. This was not uncommon with powder. There again another difficulty seemed to present itself.

Gelatine dynamite and gelignite were then recommended, and no occurrence of the kind just named took place in their use; but the fact still remained that these compounds were not altogether flameless.

In the meantime other explosives of a similar character came into the market, such as roburite, securite, carbonite, etc.

Roburite was tried; but there was some difficulty in keeping it in proper condition for use. In storing, it was subject to liquefaction, and difficulty was experienced in its not being in the best or fit condition when required for firing; and although fired by battery with a very powerful detonator, missed shots were very numerous, and it was by no means uncommon to gather up cartridges or bobbins on the screens and picking bands. In some cases only half the cartridge had exploded—that would be in cases where perhaps two bobbins had been used—and only the first or part of the first had exploded. Here again on one occasion the deputy on examining after firing observed the place illuminated by a bluish coloured light proceeding from the fallen coal; this, the writer attributed to be from a portion of an unexploded cartridge burning through flame or heat produced by the explosion or detonation. In consequence of the trouble it seemed to be giving all over the pit in missed shots, etc., its use was discontinued. But in all fairness, the writer should say that this refers to roburite at a very early period of its introduction.

Since then he has used gelignite, which has altogether been more satisfactory in general use, both as regards the collier and the management. There has been no trouble with it.

After these experiences, the writer has formed an opinion which, however, is open to criticism.

The ground he takes principally is, he believes that no explosive in use at present is, or can be, employed without production of flame or excessive heat in some form or other. The greater the attempt to produce a compound said to be flameless, or to condense or destroy flame, the greater in proportion the igniting power required; indeed to such an extent as to become a powerful explosive of itself, and in some cases, in volume much like an ordinary charge of gunpowder, giving off or emitting

necessarily a large flame or heat in comparison. To this something may be added on account of friction. The writer has no evidence to adduce beyond the idea that an explosion must be accompanied by friction, and that being so, he thinks a share of flame or heat may be attributed to this source. He is at the same time not yet convinced either by experience or tests, or any information so far gathered on the subject, that the explosives employed do not contribute to flame in the blast, or at any rate that they do not produce an intensity of heat much higher than that required for igniting gas. As somewhat in support of this, immediately following a blast, he has found the coal which has been blown from the base of the hole, to be very hot, and even exhibiting a charred appearance. In stone, the heat is much more intense.

He might instance an accident which occurred at a large colliery a few months ago, when some gas was ignited, burning several men, two, he believes, fatally. Before firing the shot there does not appear to have been an accumulation of gas in the working place, but gas was evidently liberated from the coal in the immediate vicinity of the hole. The explosive used was said to be roburite fired by a fuse and detonator. It was conjectured at the enquiry that the burning of the fuse lit gas liberated or issuing from a break, and it was expressed that had a battery been used instead of a fuse, in all probability the accident might not have occurred. The other source of danger—the detonator—he does not remember having been taken into consideration. The writer was rather inclined to believe at the time that the detonator might have been a more active agent than the burning fuse; as he thinks it would be found that a burning fuse would fail to produce a light if applied to a jet of gas in ordinary fittings. Moreover, the product of combustion due to the burning of the fuse would operate against the production of flame by it. The writer's remarks here, however, must not be interpreted that he favours the use of fuse with the higher explosives.

Coming now to the more general use of explosives. There is no doubt that as regards the manner of doing its work gunpowder is preferred, but the results would at least prohibit its use in dusty mines or pits worked by safety-lamps. The simplicity of handling powder favours the idea that, compared with other explosives, it is much safer. The writer's idea, however, is different, as gunpowder is easy to ignite under almost any conditions, and it is more lightly treated than other explosives with which the men are not so familiar. The improvements now made in the lower standards of nitro-glycerine and other compounds, in the efforts to produce non-freezing and, as nearly as possible, flameless explosives, have greatly reduced the danger, and no doubt made them safer to handle than gunpowder; but it should always be remembered, in dealing with them, that the function of an explosive is to explode. There can be no question that blasting powder is the best adapted for coal-getting, and the writer cannot help feeling that much may be done to improve this useful agent by raising the standard quality. There appears to be no restriction as to this as in the case of nitro-glycerine and similar compounds. Why should not blasting powder be made to produce much less flame, instead of the "blaze-out" stuff that can be purchased at a price much less than that of saltpetre, of which it

should be largely composed? He thinks this is a subject well worthy of the attention of mining bodies. While advocating improvement in the standard of blasting powder, he does not anticipate that it would ever take the place of the higher explosives, but it might be made safer and more useful at least in other mines than those he has specified.

With regard to the practice of shot-firing—apart from the Mines Act, the conditions of which are very clearly laid down—the merest common-sense would suggest any precaution, so far as all that can be externally foreseen, to render the risk of explosion at least remote; but with the exercise of every care a great source of danger still lurks beneath the surface beyond inspection. The writer had a serious illustration of this in July last year, when a gas blower of extraordinary strength lifted and cut the bottoms off close to the "face." The gas came from the direction of underneath the solid coal. It filled the workings, and he estimated that there would not be less than 2½ to 3 million feet of gas, which all came within two hours. This occurred in a long range of benks about four o'clock in the morning, when no men were in these places. In the writer's experience there seems to be as much, if not really more, to fear and guard against in the contingencies underlying the coal being brought down, which can hardly be underestimated, as in the instances before adverted to.

In closing this paper he may say there are certain practical considerations which govern the choice and use of explosives, apart from any particular application of them. Indeed, speaking generally, it may be urged with much force that though theory may give good guidance as to what may be expected of an explosive, and may satisfactorily explain apparent anomalies and eccentricities in its behaviour, yet nothing short of actual trial of that explosive, under the circumstances and conditions of the places and occasions in which it is proposed to use it, will give thoroughly dependable results as to its value.

The value of powder as an agent in blasting for coal is well known, but there are conditions, as already stated, which exclude its use in some mines, where at the same time the higher explosives may be used with comparative safety.

In the adoption of modern explosives a great deal has already been accomplished, but much still remains to be done. When the short space of time since they were brought under general notice is taken into consideration, it must be confessed that considerable strides have been made in adapting them to new uses, by applying them in the removal of obstacles which nature has placed in the way of the engineer. There are fair prospects in the direction of producing a safe and desirable explosive for use in coal mining, and it may reasonably be hoped that the possibilities of disasters and minor accidents, from explosions attributable to blasting, may disappear altogether.

Mr. John Taylor's paper on "Elsom's Improved Method of Lighting Miners' Safety-Lamps while Locked" was next read.

ELSOM'S IMPROVED METHOD OF LIGHTING MINERS' SAFETY-LAMPS WHILE LOCKED.

By John Taylor, Nottingham.

An invention of an important nature in regard to the re-lighting of miners' safety-lamps while locked, has recently been patented by Mr. Henry Elsom, of 64, Old Buildings, Bulwell, which no doubt will prove of inestimable value, not only to colliery proprietors, but also to miners generally. Having been engaged in colliery work for many years, the inventor has long felt the want of some such means, not only by way of saving considerable loss of time, but in the event of an explosion, better enabling workmen to make their escape than is the case at the present. It is well known, in the event of the light being extinguished by an explosion of gas, or by concussion through falling, or from any other cause, that the miner must leave his work and go to the pit shaft, or lighting station, in order to get the lamp re-lighted, which involves, in many instances, a serious loss of time. By this invention, the lamp may be readily re-lighted by a simple and safe process, without in any way infringing the laws regulating collieries in this particular respect. On this ground alone the invention is of sufficient merit to demand its adoption and general use. There is no doubt whatever, owing to its simplicity, that it would be perfectly safe in the hands of all workmen.

It may be further observed that the lamp has been thoroughly tested with gas, with the result that it has no effect upon the matches. In all cases ordinary matches or lucifers have been used (neither the oil nor the heat of the lamp affecting them), but it is the intention of the inventor to obtain special matches to be used in the lamps.

Plate IV. explains the invention :—Fig. 1 is a vertical section of a miner's safety-lamp; Fig. 2 is an horizontal section or plan of the lower part thereof with the improvements applied; and Fig. 3 is a side elevation of the upper end of the igniter holder, showing two short matches wedged in it.

a is the oil reservoir, which is screwed to the ring *b* carrying the upper parts of the lamp, and is locked thereto in any ordinary manner; *c* is a tube which is fixed at the top and bottom of the oil reservoir, and forms a passage for the rod or wire d^1 of the wick trimmer *d*, which is constructed and operated in the well-known manner; *e* is a tube which passes through the oil reservoir *a* on the opposite side to the wick trimmer tube *c*, and is fixed at the top and bottom of the said reservoir; through this tube *e* is passed a wire or rod *f*, which is free to slide vertically; the lower end of the wire or rod *f* is either bent at a right angle to itself, or as shown at f^1, it is provided with a milled or other disc or head piece, by which the wire or rod *f* may be partially rotated and moved up and down when required. To the upper end of this wire or rod *f* is attached any suitable arrangement of lighting, whereby, when the light in the lamp is extinguished from any cause, the wick may be relit by the aid of the lighting means within the lamp, carried by the rod or wire *f*, which is operated by means of the part f^1 at its lower end and

outside of the lamp. The means of lighting shown in Plate IV. Fig 3, is only given as an illustration; it is, however, simple and capable of easy management. It consists of a double-ended socket or holder f^2, in which short Congreve or other matches capable of being ignited by friction are fixed; they project a short distance from the socket or holder f^2, and when required, can be turned one at a time towards the roughened plate or surface g secured to the side of the wick tube h or in other convenient position, and caused to ignite by friction against the roughened surface. In relighting a lamp by this means, the lamp is tilted so as to bring the wick over the match or lighter, which is turned towards the roughened surface g and moved up and down until ignited. In Plate IV. the socket or holder f^2 is shown formed to receive only two matches, but if desired it may be formed with three or more sockets to receive as many matches.

The reservoir of the lamp is provided with a projecting cylindrical or other shaped foot i, to enable the wire or rod f normally to rest with the socket or holder f^2 below the flame in the comparatively cool part of the lamp, thereby preventing accidental ignition of the lighting means. The foot i also protects both rods or wires d^1 and f^1 from injury. When employing a socket or holder f^2 provided with more than two matches, it may be advisable to fix thereto a guard plate or shield between adjacent matches to prevent the flame of one match from accidentally igniting the adjacent match.

Mr. GEORGE FOWLER (Nottingham) remarked that Mr. Elsom was present. He proceeded to briefly describe the lamp, and said by means of the invention, which was very simple, a miner could light his lamp twice himself. He did not see that there was any more risk than with the ordinary lamp. Either Mr. Elsom or himself would be pleased to answer questions.

Mr. ELSOM then exhibited one of his lamps.

Mr. HENRY LEWIS (Annesley) asked what would be the effect if the light were extinguished by gas, and the interior of the lamp was filled with gas? Would it light the matches?

Mr. ELSOM—No. It would not touch them. The lamp has been thoroughly tested.

Mr. EMERSON BAINBRIDGE pointed out that if the lamp flame were extinguished by gas, the effect, when the match was afterwards struck, would be just the same upon the match, the flame of which would go out.

Mr. H. LEWIS—Does the match work equally well whether the lamp is warm or not? Let us see the match act.

Mr. ELSOM—Yes. (He then struck the match in the locked lamp, which failed to ignite. A second and a third attempt, however, were both successful.)

The CHAIRMAN asked Mr. Stokes if there was not a rule that no matches be taken into a mine? He would like to know how the inventor was going to get over that?

Mr. A. H. STOKES (H.M. Inspector of Mines, Midland District)—We should have to get the rule altered.

To illustrate Mr. John Taylor's paper "On Elsom's Improved Method of Lighting Safety-Lamps while Locked."

FIG. 1.

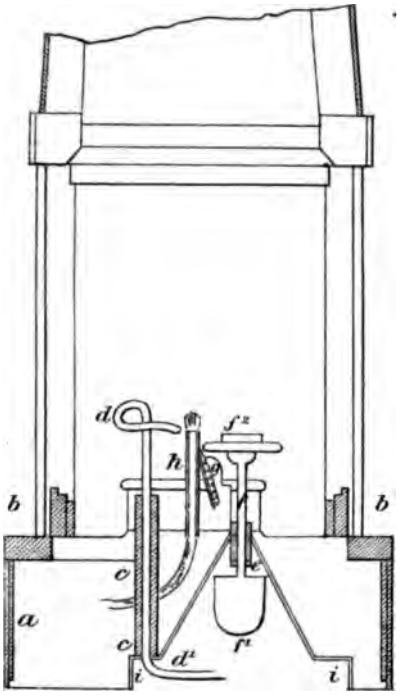


FIG. 2.

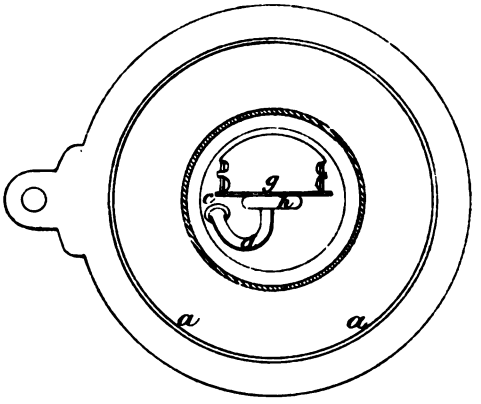
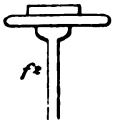


FIG. 3.



ANDREW REID SONS & CO. LTD. NEWCASTLE

Mr. J. S. MARTIN (H.M. Inspector of Mines, Bristol) said that in Westphalia there was a lamp in use known as the "Wolff" lamp, which could be frequently relit. He saw one lighted seven or eight times when it was shown at a meeting of the Manchester Geological Society in March, 1884.

Mr. ELSOM (in answer to Mr. Bainbridge and Mr. H. Lewis) stated that the lighting arrangement could be applied at a low cost, and could be adapted to old lamps by casting fresh bottoms, making the ring larger to provide room for the lighting apparatus, and the bottom a little wider. He also stated that he could apply about a hundred matches to lamps in about a minute. The lamps were not yet in actual use.

Mr. A. H. STOKES said there was one point which had not been touched upon. Supposing whilst the men were working there was a quantity of gas coming off in the workings which made the ventilation an explosive mixture, what would be the effect if a man's lamp went out owing to the gas coming across the working place, and he immediately struck one of the matches whilst the lamp was full of such explosive mixture?

Mr. ELSOM—It would not light it.

Mr. BAINBRIDGE said that if the gas put out the lamp in the first place, it would also put out the match.

Mr. STOKES said that was not quite the point. An explosive mixture sometimes passed through a lamp and was of a nature to be repeatedly ignited. Miners frequently met with cases where they might try for gas and the ignition put out the light, and then on trying again and again the gas would ignite and put out the light. If the volume of gas was so large in quantity as not to ignite, then certainly there would be no danger from striking the match. His remarks alluded to explosive mixtures.

Mr. T. A. SOUTHERN—Might I suggest one other objection—the case of a workman letting his lamp fall. Is it desirable that he should be able to relight it without its having been re-examined? It might have been damaged in falling.

The CHAIRMAN said the invention was a useful idea, but he thought himself that nothing should be placed in the miner's hand that would enable him to light his lamp himself. The rules were very stringent, and a great deal of trouble was taken to ensure the safety of the miner by only allowing the lamps to be lit by a responsible person; and he thought it would be dangerous if they were to place in the hands of the miners the power of lighting their own lamps. Although he would progress as much as anyone, he thought this matter deserved their careful consideration before getting powers to adopt it.

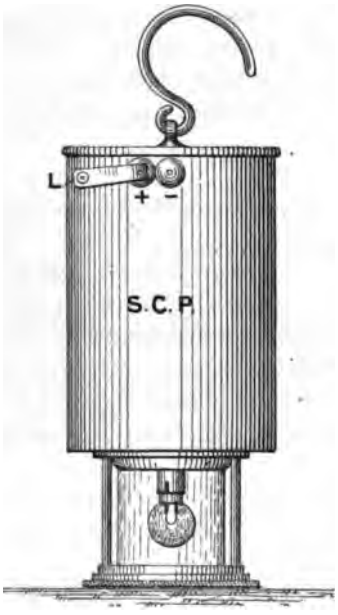
The CHAIRMAN then said that he was sure the members would be interested in electric lamps, and as Mr. Smith was there he would doubtless give an explanation of the one before them.

Mr. G. E. SMITH read the following account of "The S.C.P. Miner's Electric Safety-Lamp":—

THE S.C.P. MINER'S ELECTRIC SAFETY-LAMP.

By G. E. Smith, Nottingham.

It is claimed for this lamp that it more nearly resembles, in size and form, the ordinary oil safety-lamps in general use, than any other yet invented. By unscrewing the bottom, the lamp or bulb can be replaced by a new one in a few seconds; and, in the same way, the lamp glass, which is of the ordinary or standard size now in general use, can also be replaced the same as in the oil form of safety-lamp. Another feature is that each of the cells composing the battery is separate and independent, and should any accident or fault require one or more of these cells to be replaced, it can (unlike those now in use) be done in a few minutes at the colliery, spare cells being supplied and kept in stock. This fact is of great importance, for in the older forms, if one cell failed the light became dull, and there was no means of telling which identical cell it was; but in these lamps if any irregularity is observed, each cell can be tested in a few minutes with the voltmeter, and the bad cell taken out, a new one put in, and the lamp sent into the pit as usual; thus saving many extra lamps being required: whereas in the ordinary forms, the lamp has to be returned to the maker, causing both delay and expense. This advantage is said to avoid many of the irregularities found in other electric safety-lamps.



The cells are made with a special plate, which gives greater electric capacity for a given weight than any other. It has a high charge retaining power, is free from local action and sulphating, and there is little or no deterioration of the plate. There is a plate here, taken from a battery that has been two and a half years in use, which shows how far this statement is borne out in practice.

The battery is of the storage or secondary type, and is contained in a circular metal case, avoiding the use of wood, which has hitherto been too prominent a feature in electric miners' lamps. There are two small studs, called charging points, marked + and −, at which the dynamo machine is connected to recharge the lamp, and from a third similar stud a small strap of metal unites + and L, and lights the lamp. A nut screws on +, and can be so shaped that it can only be removed by a special key, thus (if necessary) forming a lock as in the old safety-lamp. The lamp on the table has nothing of the nature of a lock, and it was not considered necessary, as the miner cannot by any possible means get at the light, or obtain a light to any

combustible material. Should he succeed in taking out the bulb, the light immediately goes out; and if he replaces the bulb the lamp immediately re-lights itself, as this one now does. The lamp is furnished with the usual "S" hook handle in place of the leather handle too often seen in new forms of electric safety-lamps. The smaller lamp is said to burn 7 or 8 hours; the larger one 10 hours. The smaller lamp weighs about 3¾ lbs., and is reported to give 15 per cent. more light than an ordinary safety-lamp. The larger lamp is double the size of the smaller one; it contains double the number of cells, and gives double the light, and is of course heavier in weight.

This lamp obtained a silver medal at the recent Falmouth Exhibition of the Royal Cornwall Polytechnic Society. It is made by Messrs. Cathcart & Peto, of London, from designs furnished by the writer, and is of very recent manufacture; so early has it been brought before this Institution that the price is not yet decided upon, but the makers hope to be able to produce it at a price within the reach of colliery proprietors and engineers.

Members will have an opportunity this afternoon of seeing the lamp in the process of being refilled or recharged by a dynamo machine. It takes about 4 or 5 hours to refill the smaller one, and about 6 or 8 hours to fill the larger one; this is done of course during the night when the lamps are not required in the mines; it is possible to refill the lamps in a shorter time, but the slower charging is to be preferred.

If desired a lamp can be supplied (in addition to the one at the bottom) which can be readly fixed on + and − for examining the roof or for any other purpose. The lamp is lighted immediately on being placed in position, and is extinguished upon being removed.

Mr. T. A. SOUTHERN—Has the durability of the lamp been tested?

Mr. SMITH—The batteries have been in use over two years. The lamp in its present form is quite new. If the lamp is to burn for eight hours, it requires six hours for charging. We have no actual record showing the required horse-power, but I should say, that with a dynamo giving 50 volts, if 6, 8, or 10 lamps are placed in series, then about ten such batches, *i.e.*, 60 to 100 lamps, would require one horse-power. There has not been opportunity to test these things owing to an accident at the manufactory. Of course, the number of lamps per horse-power depends on their size. The cells contain liquid, and are fitted with a screw top with a very small hole in it, so as to allow the gas to escape, but if turned on one side it will not allow the liquid to flow out.

Mr. W. B. SCOTT (H.M. Inspector of Mines, Birmingham)—Is the battery liable to give trouble by short circuiting?

Mr. SMITH—The inventor hopes by making each cell independent of the others to avoid short circuiting. In answer to another question, he (Mr. Smith) said the maker informed him that one of the lamps had fallen off a shelf two or three feet from the ground, and had been uninjured.

Mr. H. LEWIS—Does it take six or eight hours to recharge? That would be great inconvenience.

Mr. SMITH—It is better to charge the lamps slowly when they are off duty. A quicker charge could be given, but the slow one is preferable.

Mr. WILLIAM SPENCER (Leicester)—I would like to ask whether at the end of eight hours you have to recharge? My experience is, with another lamp, that it wanes considerably before the end of eight hours.

Mr. SMITH—When the accumulators in the lamp get down the light gradually becomes weaker, and the lamp goes out. At the end of eight hours the light would begin to get dull; it might burn for nine or ten hours, but the light would be continually becoming duller. It is unwise to use the lamp after it has run its full time.

Mr. H. LEWIS—Have you burnt the lamp eight hours yourself?

Mr. SMITH—No, I have not. It has only been finished a short time, and I have not had the opportunity.

Mr. SOUTHERN—What is the candle-power?

Mr. SMITH—The larger is called three, and the smaller two candle-power.

Mr. GEORGE LEWIS said he thought the invention was a step in the right direction. He hoped before long they would have an electric lamp which would really be found of some practical use in mines. Up to the present he had seen nothing at all approaching what they wanted; but he must say the lamp before them appeared to be a very useful one, and he hoped efforts would be made by those having a knowledge of electricity to produce a lamp suitable to mining requirements.

Mr. M. WALTON BROWN said there was another point. If there was any gas in the mine the present lamp would not show it. It ought to be made to do so.

Mr. SMITH said they had thought of introducing platinum wire. The lamp was only in its infancy, and it would be for the maker to think these points carefully over. It could also be made to give more light afterwards.

Mr. SOUTHERN—You can tilt it? Would the lamp burn upside down?

Mr. SMITH—Yes; but the acid might spill. The maker had thought of putting the light at the top; to that, however, mining engineers had objected as there would be greater liability to damage from falls of roof. Practically the light might be put at the top or at the bottom of the lamp as desired. It was not advisable to tilt it too much on the side because of the small holes. A little of the acid might leak out.

The CHAIRMAN—I am sure we are very much obliged to Mr. Smith for bringing the lamp before our notice.

The CHAIRMAN said he wished them to give a hearty vote of thanks to the Mayor and Corporation for their kindness in lending them these buildings, and to the University Professors for the assistance they had given them.

Mr. H. LEWIS seconded the motion, which was carried unanimously.

The CHAIRMAN moved that the Secretary convey their thanks to all the other gentlemen who had thrown open their works for inspection, and who had assisted in the arrangements for their meeting in Nottingham.

Mr. E. BAINBRIDGE seconded the resolution, which was carried.

Mr. GEORGE LEWIS proposed a vote of thanks to the Chairman, which was carried amid applause, and the meeting terminated.

EXCURSIONS MADE DURING THE VISIT OF THE FEDERATED INSTITUTION OF MINING ENGINEERS TO NOTTINGHAM.

September 24th, 1890.

The following works and places of interest in the town were, by kind permission of the owners and authorities, open to the members, and at the close of the General Meeting parties visited :—

(1) The University Buildings, including the College, Museum, and Free Library of the Corporation. The party was conducted by the Professors of the College.

(2) The Corporation Gas Works at Basford (Mr. W. R. Chester, Engineer and General Manager), the features of interest being—coke breaking and washing machinery; coal testing appliances; general buildings. At the Eastcroft Gas Works, regenerator furnaces were seen.

(3) Mr. Bull's Hosiery Manufactory, Messrs. Kirk & Sons' Lace Manufactory, and Mr. A. Towle's Lace Manufactory, in Great Alfred Street. At Mr. G. E. Smith's works were exhibited an improved form of miner's electric lamp, and the S.C.P. Miner's Electric Safety-Lamp, together with the process of charging the lamps.

The members dined at the George Hotel in the evening.

The High Sheriff for the County of Nottingham, Charles Seely, Esq., afterwards entertained the members and their friends at Nottingham Castle.

September 25th, 1890.

Three routes were open for selection by the members, and each was well attended. The following notes record some of the features of interest seen by each of the parties :—

ROUTE No. 1.

HUCKNALL TORKARD COLLIERIES.

No. 1 COLLIERY.

SHAFTS.—Two, 11 feet diameter; depth, 386 yards; working Top Hard Coal.

CAGES.—One in each shaft; 3 decks, one above another; unloaded without changing by Fowler's hydraulic rams, with similar arrangement at pit bottom.

BOILERS.—Six Lancashire and six egg-end.

WINDING ENGINES.—A pair of 30 inch cylinders by 5 feet stroke, 14 feet drum, and load 39 cwt. coal.

GUIBAL FAN.—36 feet diameter by 12 feet wide, driven by a pair of 30 inch by 30 inch engines, worked alternately, 50 revolutions per minute.

UNDERGROUND AUXILIARY FAN.—Walker Guibal fan, ventilating far-off district; 15 feet diameter; driven by two 23 inch engines with cotton ropes, producing 6 inches of water-gauge.

SORTING BELT.—200 feet long by 2 feet 9 inches wide, travelling belt to screens, coal tippler, etc.

UNDERGROUND HAULAGE.—Endless chain.

No. 2 Colliery.

Shafts.—Two, 12 feet diameter; depth, 416 yards; working Top Hard Coal.

Winding Engines.—A pair of 36 inch diameter by 6 feet stroke; drum, 16 feet; load, 50 cwts. coal.

Cages.—One in each shaft, 4 decks, one above another; bank divided into two levels for changing quickly.

Ventilation.—Furnaces and underground boilers.

Coal Sorting.—Hand-picking.

Underground Haulage.—Endless chain.

LINBY COLLIERY.

Shafts.—Two; working Top Hard Coal.

Sorting Belts.—Single.

Air Compressor.

Underground Haulage.

Luncheon was given by the owners.

ANNESLEY COLLIERY.

Shafts.—Two; working Top Hard Coal.

Sorting Belts.—Double and single.

Underground Haulage.

Boilers.—Caddy's patent bars for smoke consuming.

NEWSTEAD COLLIERY.

Shafts.—Two; working Top Hard Coal.

Winding Engines.—Two pairs of vertical winding engines, 4 feet cylinders and 6 feet stroke.

Air Compressing Engines.—One pair of air compressors; diameter of steam cylinders, 33 inches; diameter of air cylinders, 35 inches; stroke, 4 feet 6 inches.

Surface Hauling Engines.—One pair 24 inch cylinders and 3 feet stroke; geared 5 to 1.

Ventilation.—Two duplicate fan engines, each cylinder 30 inches diameter and 2 feet 6 inches stroke, coupled to duplicate Guibal fans 36 feet diameter and 12 feet wide. Only one fan runs at once.

Sorting Belt.—220 feet long by 40 inches wide, with elevator and jigging screens; driven by one 11½ inch cylinder by 2 feet stroke.

Boilers.—Twenty-one Lancashire boilers, 28 feet long and 7 feet diameter; all coupled together.

NEWSTEAD ABBEY.

This historic house, as well as the gardens and park, now the residence of W. F Webb, Esq., was specially opened to the visitors.

ROUTE No. 2.

CLIFTON COLLIERY.

SHAFTS.—Two, 14 feet and 13 feet diameter, 256 yards deep; sunk to and working the Deep Hard Coal (4 feet 6 inches thick), also working the Deep Soft Coal (3 feet 6 inches thick), 242 yards deep in the shafts. About 300 yards south of the pits the seams are thrown down 95 yards, and the coal is now being raised that height in addition to the depth of the shafts.

BOILERS.—Seven Lancashire, 30 feet by 7 feet, feed-water supplied by two exhaust steam injectors at a temperature of 204 degs. Fahr.

WINDING ENGINES.—No. 1 pit (downcast, 14 feet diameter), high pressure horizontal engine, 2 cylinders, 30 inches diameter, 5 feet stroke; drum, 15 feet diameter; single deck cage carrying 2 tubs, each holding 12 cwt. of coal.

No. 2 pit (upcast, 13 feet diameter), high pressure horizontal engine; 2 cylinders, 26 inches diameter, 5 feet stroke; drum, 12 feet diameter; single deck cage carrying 2 tubs, each holding 12 cwt. of coal.

SIGNALLING.—Electric signals from surface to bottom of shafts, and from bottom of shafts to surface.

BANKING AND SCREENING.—Self-acting arrangement for unloading and loading the cages; automatic duplex tippler; coal sorting band, 200 feet long; and jigging screens.

AIR COMPRESSING ENGINES.—Pair of high pressure horizontal air compressing engines, air and steam cylinders, 30 inches diameter, 4 feet stroke, supplying air at 60 lbs. pressure per square inch to two pairs of hauling engines underground.

VENTILATION.—Guibal fan, 40 feet diameter by 12 feet wide, taking in air on both sides, driven by compound and condensing engines; high pressure cylinders, 18 inches diameter; low pressure cylinders, 33 inches diameter, 2 feet 6 inches stroke. Fan drifts below the level of the River Trent, and lined with cast iron tubbing.

The party drove through Wollaton Park, the seat of Lord Middleton.

WOLLATON COLLIERY.

SHAFTS.—200 yards deep—Two winding, 14 feet diameter; upcast, 12 feet. Working Deep Hard and Deep Soft Coal.

WINDING ENGINES.—Two pairs coupled horizontal winding engines, 30 inch cylinders, 5 feet stroke; drums, 14 feet diameter.

SORTING BELT.—200 feet long; jigging screens, etc.

AIR COMPRESSOR.—Compound high pressure cylinder, 38 inches; low pressure, 60 inches; air cylinders, 40 inches.

GUIBAL FAN.—44 feet by 12 feet.

WORKSHOPS.

SIDINGS.—Wagons falling by their own gravity, and worked without locomotive.

Luncheon was given by the Owners.

CINDER HILL COLLIERY.

SHAFTS.—Two, 7 feet and one 10 feet diameter, working Top Hard Coal.

WINDING ENGINE.—Single cylinder, 40 inches diameter, 5 feet stroke, drawing from a depth of 222 yards, and working in conjunction with Fowler's hydraulic landing arrangement.

HAULAGE MACHINERY.—Endless rope, main and tail, single rope, and endless rope driving haulage drums.

BANKING ARRANGEMENTS.—Sorting band, 307 feet long, 3 feet wide, dealing with over 1,000 tons per day.

BRICKWORKS.—Roller mill, endless chain, and Hoffman kiln.

BESTWOOD COLLIERY.

SHAFTS.—Two, 13 feet 6 inches diameter; depth, 404 yards; working Top Hard Coal.

HEADGEAR.—Wrought iron latticed, with 18 feet pulleys.

BOILERS.—Seven Galloway and five Kesterton boilers, all of which are fired by Juckes mechanical stokers.

WINDING ENGINES.—A pair of vertical winding engines, 36 inch cylinders by 6 feet stroke; 19 feet drum. A pair of horizontal winding engines, 30 inch cylinders by 5 feet 6 inches stroke; 18 feet drum.

AIR COMPRESSING ENGINES.—Two; one a single horizontal, steam and air cylinders each 42 inches by 6 feet stroke, and the other a compound beam engine, high-pressure cylinder, 30 inches by 4 feet 1 inch stroke; low pressure cylinder, 46½ inches by 8 feet 2 inches stroke.

GUIBAL FAN.—46 feet diameter by 15 feet, driven by a pair of compound marine engines.

SCREENING ARRANGEMENTS.—Ordinary.

WORKSHOPS.—Fitted throughout with various wood and iron working machinery.

The party drove through Bestwood Park, the seat of the Duke of St. Albans.

BESTWOOD PUMPING STATION.

WELL.—200 feet deep, sunk in the Bunter Beds of the New Red Sandstone, and yielding an abundant supply of beautifully clear and palatable water of medium hardness. Six bore-holes are sunk into the clay.

BOILERS.—Six Lancashire boilers, by Witham, of Leeds, working in two sets of three each.

ENGINES.—A pair of single cylinder beam engines, working expansively (cut-off, ⅛th stroke), lifting water 200 feet from the well, and forcing it 90 feet into a surface reservoir. The whole of the works and plant, designed and carried out by Messrs. T. & C. Hawksley, engineers, in 1870-72, and transferred to the Nottingham Corporation in 1880.

The Chairman (Mr. Ald. Gripper and the Vice-Chairman (Mr. Ald. Cropper) of the Water Works Committee, with Mr. L. T. Godfrey-Evans, the engineer, conducted the party.

Route No. 3.

LEICESTERSHIRE IRONSTONE WORKINGS IN THE LIAS FORMATION.

The party went by Great Northern Railway to Harby and Stathern Station, and drove thence by brakes to the Eastwell Iron Company's, the Holwell Iron Company's, and the Eaton Iron Company's, ironstone workings.

The party had luncheon at Belvoir Inn, and then drove to Belvoir Castle and grounds, the seat of the Duke of Rutland, and returned by Great Northern Railway from Bottisford Station to Nottingham.

CHESTERFIELD AND MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

MEETING,

HELD AT NOTTINGHAM ON SEPTEMBER 24TH, 1890.

MR. JOHN JACKSON, PRESIDENT, IN THE CHAIR.

The following were found duly elected Members and Associate Members of the Chesterfield Institution:—

MEMBERS—

Mr. Alfred Thomas Holland Barnes, Mining Engineer, Grassmoor Collieries, Chesterfield.

Mr. Arthur Gorell Barnes, Civil and Mining Engineer, Grassmoor Collieries, Chesterfield.

Mr. George Buxton, Mechanical Engineer, Albion Foundry, Melton Mowbray.

Mr. James Diamond, Mechanical Engineer, Pye Bridge Chemical Works, Pye Bridge, Alfreton.

Mr. Charles Paxton Markham, Mechanical Engineer, Chesterfield.

Mr. Thomas Henry May, Mining Engineer and Surveyor, Times Buildings, Bow Street, Sheffield.

Mr. William Melling, Mining Engineer, South Leicestershire Colliery, Coalville, near Leicester.

Mr. Cuthbert John Oliver, Engineer and Surveyor, Spring Vale, Spital, Chesterfield.

Mr. Henry Stevenson, Colliery Manager, Portland Collieries, near Alfreton.

Mr. Thomas Williamson, Mining Engineer, West Hallam Collieries, Ilkeston.

Mr. Joseph Wright, Colliery Proprietor, Arboretum Street, Nottingham.

ASSOCIATE MEMBERS—

Mr. George Hall, Foreman Pattern Maker, Brassington Street, Clay Cross.

Mr. Alfred Heslington, Under-Manager, New Tupton, near Chesterfield.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
OCTOBER 11TH, 1890.

MR. A. L. STEAVENSON, IN THE CHAIR.

The minutes of the last meeting were read and confirmed.

The CHAIRMAN said the time had now arrived for the election of the representatives of this Institute on the Council of the Federated Institution for the ensuing year, and the Council suggested that the present representatives should be re-elected. If this course were adopted considerable time and trouble would be saved. The co-optated members of Council who represented this Institute would be, as the name implied, elected by the Council themselves.

Professor J. H. MERIVALE moved the appointment of the present representatives.

Mr. R. THOMPSON seconded the resolution, which was carried unanimously.

The names of the representatives on the Council of the Federated Institution of Mining Engineers are:—

1.—W. Armstrong, Jun., Esq., Wingate, Co. Durham.
2.—Sir Lowthian Bell, Bart., D.C.L., F.R.S., Rounton Grange, Northallerton.
3.—M. Walton Brown, Esq., 3, Summerhill Terrace, Newcastle-upon-Tyne.
4.—W. Cochrane, Esq., Grainger Street West, Newcastle-upon-Tyne.
5.—John Daglish, Esq., F.G.S., Marsden, South Shields.
6.—T. Douglas, Esq., Peases' West Collieries, Darlington.
7.—G. B. Forster, Esq., M.A., F.G.S., North Jesmond, Newcastle-upon-Tyne.
8.—G. C. Greenwell, Esq., F.G.S., Elm Tree Lodge, Duffield, Derby.
9.—G. May, Esq., Harton Colliery, South Shields.
10.—John Marley, Esq., Thornfield, Darlington.
11.—J. B. Simpson, Esq., F.G.S., Hedgefield House, Blaydon-upon-Tyne.
12.—A. L. Steavenson, Esq., Durham.
13.—James Willis, Esq., H.M. Inspector of Mines, 14, Portland Terrace, Newcastle-upon-Tyne.
14.—Lindsay Wood, Esq., Hermitage, Chester-le-Street.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. George Bradford, Colliery Viewer, Witton Park, Darlington.

Mr. George Arthur Mitcheson, Mining Engineer, Dresden, Longton, Staffordshire.

Mr. William Ryder Stobart, Mining Engineer, Etherley Lodge, Darlington.

Mr. Thomas Watson, Mining Engineer, Trimdon Colliery, Trimdon Grange.

ASSOCIATE MEMBER—

Mr. William Cochran Carr, Coal Owner, Benwell Colliery, Newcastle-upon-Tyne.

ASSOCIATE—

Mr. Thomas Clark, Under-Manager, Dipton Colliery, Lintz Green Station.

STUDENT—

Mr. George Murray Andrews, B.A., Mining Student, Broomhill Colliery, Northumberland.

The following gentlemen were nominated for election:—

MEMBERS—

Mr. James Burn, Mechanical Engineer, etc., 28, Fawcett Street, Sunderland.

Mr. William Rochester, Colliery Manager, River View, Blaydon-on-Tyne.

Mr. Francis H. Spencer, Mining Engineer, Robinson Gold Mining Company, Witwatersrand.

Mr. Hugh Waddle, Mechanical Engineer, Llanmore Iron Works, Llanelly, South Wales.

ASSOCIATE—

Mr. William Stephenson, Under-Manager, Garesfield Colliery, Lintz Green.

Mr. M. WALTON BROWN read his paper, communicated by the Explosives Committee, on "Experiments with Explosives used in Mines."

EXPERIMENTS WITH EXPLOSIVES USED IN MINES.

By M. Walton Brown.

An interesting series of experiments with explosives used in mines were made on August 25th, 1890, at the Cymmer Collieries, Glamorganshire, at which the writer attended, on the invitation of Messrs. George Insole & Sons, the proprietors.

I.—Description of the Apparatus (Plate V.).

The apparatus consists essentially of a cannon *a* and a gas chamber *b*.

The cannon *a* is a steel block (securely hooped with steel rings) 2 feet 6 inches long and 1 foot 8 inches diameter, with a 2 inch hole about 1 foot 8 inches long.

The gas chamber *b* is formed in a cylindrical boiler 5 feet 11 inches diameter and 18 feet long, one of whose convex ends is removed. The boiler is firmly bedded in the ground, and the closed convex end and the cannon (partially inside the boiler) is securely built into a block *c* of cemented masonry. The cannon is placed so that the shot hole points obliquely upwards at an angle of about 15 degs. to the axis of the boiler.

A wooden ring 3 inches square *d* is bolted on the inside shell of the boiler, 9 feet from the end, to which a circular piece of brattice cloth *e* is attached in each experiment. By this means a closed chamber *b* is formed in the boiler with a capacity of about 300 cubic feet.

About 9 inches from the closed end, and on the top of the boiler, there is a small hole *f* through which the firing cable *g* is led from the magneto-electric exploder. At about 3½ feet from the same end there is a square opening *h* of 13 inches, fitted with a wooden seat *i* covered with flannel, and closed by a wooden lid or valve *k* (weighing 12 pounds) attached to a rope. At about 8 feet from the other end of the boiler there is a hole *l*, 13 inches by 5 inches, covered by an iron plate *m*, ½ inch thick, fitted with bolt and bridge like a man-hole cover.

A small fan *n* is fitted about 18 inches from end of boiler, and in front of the cannon. It consists of a light iron rod with a cranked handle at one end, which is passed from side to side through the boiler, and fitted on each side of the axis of the boiler with two plates of tin 15 inches by 18 inches, which act as fan blades when the iron rod is turned by the external handle. These tin plates have two holes at their edges, through which the iron rod is passed.

The gas for the experiments is procured from a large blower in the 2 feet 9 inch seam, whence it is led to a large receiver-meter about 10 yards from the boiler, by

which the gas is measured out into the chamber through a pipe *o* attached to the round end of the boiler, and in front of the steel cannon. The gas used has an approximate composition of—

Marsh gas	96·0
Carbon dioxide	·5
Nitrogen	3·0
Oxygen	·5

From the experiments of the French Explosive Substances Commission, it appears that the apparent temperature of ignition of a mixture of fire-damp and air is about 3,992 degs. Fahr., and that of a mixture of coal-gas and air is about 3,812 degs. Fahr. It is evident, therefore, that the inflammability of mixtures of coal gas and air, and of fire-damp and air, are practically the same.

Each charge is fired with one $\frac{B}{6}$ detonator, by means of a Nobel magneto-electric exploder.

II.—Mode of Carrying Out the Experiments.

The experiments were carried out under the superintendence of Mr. T. Griffiths, manager of the colliery, assisted by Mr. Joan Evans, under manager, and Mr. J. D. Lewis, and were intended to show the results of shots fired without stemming into an explosive atmosphere, *i.e.*, a mixture of air with 10 per cent. of natural mine gas, and charged with coal dust.

The charges were fired without stemming, and a charge of 3 ounces of blasting gelatine was used in experiment 8, in order to avoid any risk of bursting the steel cannon, and consequent danger to the observers.

Several objections were made to the mode of carrying out the experiments; it being said that no one would attempt to fire explosives without stemming in a fiery colliery. It was arranged, however, that although the conditions were such as did not ordinarily occur in the mine, it would be instructive to proceed to this extreme, and make the experiments under severe conditions, all the explosives being treated precisely alike, *i.e.*, igniting them when unstemmed in the shot hole.

The experiments were conducted as follows:—

The valve *k* being open, and the brattice cloth not attached to the ring *d*, the charge, with the detonator inserted, and connected to the firing cable, was placed in the cannon, and pressed to the bottom, without any tamping or stemming being used.

The valve *k* was then placed in position, and the circular piece of brattice cloth *e* was tacked to the wooden ring *d*, and 30 cubic feet of the gas, measured by the meter, was passed into this closed chamber, during which time the fan was turned rapidly, in order to mix the gases. A shovelful (about 7 pounds) of fine coal dust was then thrown into the chamber at the valve *k*, and the fan turned rapidly until it was assumed that the gases and coal dust were thoroughly mixed. The mixture was, in most cases, tested with a Davy lamp, by removing the brattice cloth near the top and bottom of boiler, by Mr. Robson, H.M. Inspector of Mines, in order to ascertain whether it was actually inflammable.

The axle of the fan was then drawn out, and the tin plates allowed to fall to the bottom of the chamber, the axle hole was plugged, and after a short interval the charge was fired.

No observations were made as to the temperature of the air in the boiler, of the shell of the boiler, or of the cannon; but the hand revealed a marked rise in the temperature of the shell of the boiler and of the cannon. No special attention was given to the airing of the boiler, and the coal dust, coke crusts, paper, etc., were allowed to accumulate in the boiler during the course of the first six experiments, except such as might be blown out by the effects of each experiment. It was swept out prior to experiments 7, 8, 11, and 15.

III.—Description of the Explosives Tested.

Ammonite.—This consists of a mixture of 10 parts of mononitro-naphthalene with 90 parts of nitrate of ammonia, enclosed in a thin tin case fitted with a projecting nipple at the closed end to receive the detonator and closed with a screwed cover at the other end. This air-tight case should render this explosive impervious to damp and climatic changes. It is claimed that this explosive, with a minimum of one inch of stemming, will not ignite an explosive mixture of air and gas.

Bellite.—This consists of a mixture of about 80 parts of nitrate of ammonia with about 20 parts of meta-dinitro-benzol. The cartridges are compressed and coated with waterproof substance, and enclosed in strong paper wrapping; thus protected .t is said to be capable of being stored for years without deterioration. This protective casing should allow of its convenient use in wet shot holes. It is said to be of great explosive power, and incapable, when stemmed, of igniting fire-damp or coal dust.

Blasting Gelatine.—This is a gelatinous mass containing from 93 to 95 parts of nitro-glycerine and 7 to 5 parts of nitro-cotton. The explosive is enclosed in strong paper covers. It is claimed that this explosive is flameless, when fired in a water cartridge. The water cartridge cases are made of specially prepared impermeable paper, fitted with tin supports, by which the explosive is maintained in a central position and surrounded by the water.

Carbonite.—This explosive has a brown granular appearance, and consists of 25 parts of nitro-glycerine, ½ part of sulphuretted benzol, 40 parts of wood meal, 34 parts of either (or both) nitrate of potash or nitrate of barytes, and ½ part of carbonate of soda. The preparation is enclosed in strong parchment paper covers. It is claimed that this preparation will not ignite explosive mixtures of air and gas. It was freely stated as the result of previous experiments that carbonite could be fired unstemmed in the shot hole in the presence of gas without igniting it.

Compressed Blasting Powder.—The sample used was of the ordinary description supplied for blasting in mines, in bobbins weighing 4 ounces each.

Roburite.—Is a mixture of nitrate of ammonia with not less than 5 per cent. and not more than 12 per cent. of chlorinated dinitro-benzol (containing not more than 4 per cent. of chlorine). The samples used appeared to be a mixture of 87

parts of nitrate of ammonia and 13 parts of chlorinated dinitro-benzol. The Roburite Company state that their explosive requires a short length of stemming in order to enable the products of combustion to act effectively, and quench all flame.

No. 1 (or Stone) Securite.—This consists of 26 parts of dinitro-benzol and 74 parts of nitrate of potash. It is enclosed in strong paper covers. This is said to be a safe explosive, but it is not claimed to be flameless.

No. 2 (or Coal) Securite.—This explosive is a mixture of 80 parts of nitrate of ammonia, 17 parts of dinitro-benzol, and 3 parts of oxalate of ammonia,. This explosive is said to be almost flameless, and when used with the patent flameless cartridge case, the little flame appears to be controlled. This case is a flannel bag, prepared with suitable chemicals, and requires to be immersed for a short time in water before use. The cartridge and attached fuse is placed in the centre of the saturated case, each end of which is then securely tied with string.

Tonite.—This mixture consists of 50 parts of gun-cotton with 50 parts of nitrate of barytes. The explosive is compressed into cartridges covered with waterproofed brown paper. Tonite may be kept for years without deterioration in any climate. It is claimed to be flameless when used with Trench's compound stemming. This flame extinguishing compound consists of sawdust impregnated with certain chemicals, and has the appearance of dirty salt. The tonite cartridge is placed in a larger brown paper casing, the intervening space being packed with the compound; or the paper case may be dispensed with, and the tonite charge placed in the hole and tamped with the compound.

It was stated that the whole of the explosives used during the experiments were supplied direct from collieries in the neighbourhood, where they were respectively in ordinary use.

IV.—Results of Experiments.

Table A contains the results of experiments 1 to 6 and 14, carried out in accordance with the programme: the whole of the explosives (except carbonite) being placed in the shot hole in the paper or other covers, the detonator being partially pushed into the end of the cartridge. The carbonite was removed from its paper cover and gently pressed to the end of the hole, the detonator being inserted and covered with the last portions of the charge.

The ignition of the gas on the explosion of the carbonite in experiment 5 may have been due to its improper preparation or sweating, or part of the charge may have contained too high a proportion of nitro-glycerine which might detonate alone and ignite the gas. Carbonite is a modification of dynamite, and may be subject to the defects of that explosive, viz., liability to freezing and exudation of the liquid nitro-glycerine on contact with water.

These experiments demonstrate with great clearness, for the explosives tried unstemmed, that none of them are flameless, and that all will ignite explosive mixtures of gas and air, charged with coal dust, when fired unstemmed.

Table B contains the results of a further series of trials which were made on the completion of experiments made in accordance with the programme suggested by Mr. T. Griffiths.

TABLE A.

Number of experiment ..	1.	2.	3.	4.	5.	6.	14.
Time .. .. .. p.m.	12·45	12·55	1·5	1·15	1·35	1·45	4·50
Name of explosive and nature of covering or case, if any.	Compressed blasting powder.	Ammonite in tin case.	No. 1 or stone securite in paper cover.	Bellite in green paper cover.	Carbonite, without paper cover.	Roburite in strong yellow paper cover.	No. 2, or coal securite, in paper cover.
Number of cartridges used..	4	2	2	4	4	2	2
Weight of each cartridge, in ounces.	4	4	4	2	2	4	4
Weight of explosive used, in ounces.	16	8	8	8	8	8	8
Number and size of detonators used.	One $\frac{R}{6}$	One $\frac{R}{6}$	One $\frac{R}{6}$	One $\frac{R}{6}$	One $\frac{R}{6}$	One $\frac{R}{6}$	One $\frac{R}{6}$
Gas used, in cubic feet ..	30	30	28	32	33	27	30
Percentage of gas in mixture	10 †	10 †	9½ †	10⅝	11	9	10 †
Coal dust used, in pounds ..	7	7	7	7	7	7	7
Results..	Ignition of mixture.	Ignition of mixture.	Ignition of mixture.	Ignition of mixture.	Ignition of mixture.	Ignition of mixture.	Ignition of mixture.
Character of explosion ..	Smart shock.	Loud report.	Louder report than last.	Weak report.	Very loud report.	Very strong report.	Sharp report.
Appearance of flame ..	Long flame issued from end of boiler.	No visible flame.	10 feet of flame issued out of end of boiler.	10 feet of flame issued out of end of boiler.	Very bright flames issued out of end of boiler and from valve.	Flame issued out of end of boiler.	Strong flames of dust and gas burnt out of end of boiler and from valve for several seconds.
Appearance of dust and smoke.	Dense clouds of dust.	Very dense smoke poured from end of boiler and from valve.	Dense smoke poured from end of boiler and from valve.	Dense smoke as before.	Dense brown and black smoke, about the same in volume as before.	Very dense smoke.	Dense clouds of smoke.
Condition of coal dust after experiment.	Burnt.	Burnt.	Burnt.	Burnt.	Burnt.	Burnt.	Burnt.
Distance the brattice was blown in yards.	5	30	30	10	35	10	About 15 yards.
Remarks	....	....	....	....	....	A small iron plate, ¼ in. thick, over a hole 5 in. by 13 in., was bent in middle _ about 45°; the wood valve was shattered and blown a few yards; and the masonry was shaken.	....

† Mixture tried with Davy lamp.

TABLE B.

Number of experiment ..	7.	8.	9.	10.	11.	12.	13.	15.
Time .. .. .. p.m.	3·5	3·20	3·35	3·50	4·10	4·30	4·40	5·5
Name of explosive and nature of covering or case, if any.	Tonite in paper cover without Trench's flame extinguishing compound.	Blasting gelatine enveloped in water cartridge.	No. 2, or coal securite, in paper cover, enveloped in a damp chemically prepared flannel bag.	Carbonite, without paper cover.	Carbonite, without paper cover.	Carbonite, without paper cover.	Carbonite in front without paper cover and bellite behind in paper cover.	Carbonite, in paper cover.
Number of cartridges used..	4	2	2	4	6	6	1 bellite. 4 carbonite.	4
Weight of each cartridge, in ounces.	2	1½	4	2	2	2	2	2
Weight of explosive used, in ounces.	8	3	8	8	12	12	10	8
Number and size of detonators used.	One $\frac{R}{6}$	One $\frac{R}{6}$	One $\frac{R}{6}$	One $\frac{R}{6}$	One $\frac{R}{6}$	One $\frac{R}{6}$	One $\frac{R}{6}$ in bellite.	One $\frac{R}{6}$
Gas used, in cubic feet ..	32	30	29	29	30	30	30	30
Percentage of gas in mixture	10½	10 †	9½ †	9½ †	10 †	10 †	10 †	10
Coal dust used, in pounds..	7	7	7	7	7	7	7	7
Results	Ignition of mixture.	No ignition of mixture.	No ignition of mixture.	No ignition of mixture.	No ignition of mixture.	No ignition of mixture.	No ignition of mixture.	No ignition of mixture.
Character of explosion ..	Strong report.	Dull report.	Sharp report.	Dull report.	Dull report.	Dull report.	Dull report.	Dull report.
Appearance of flame ..	Flames of gas (unmixed with air) and dust burnt out of end of boiler and valve for a few seconds.	No visible flame.	No flame.	No flame.	No flame.	No flame.	No flame.	No flame.
Appearance of dust and smoke.	Clouds of smoke.	....	....	Dense fumes of dust and smoke.	....	Clouds of dust and smoke.	....	....
Condition of coal dust after experiment.	Burnt.	Unburnt.	Unburnt.	Appeared to have been burnt.	Unburnt.	Unburnt.	Unburnt.	Unburnt.
Distance the brattice was blown in yards.	5 yards.	3 yards.	5 yards.	3 yards.	Brattice just blown out of boiler.	Brattice just blown out of boiler.	Brattice just blown out of boiler.	About 3 yards.
Remarks	....	....	Fly found alive in boiler.	....	....	....	....	....

† Mixture tried with Davy lamp.

Only 3 ounces of blasting gelatine were fired in experiment 8, in lieu of the 8 ounces used of all the other explosives, and strong protests were urged against such a trial.

In experiments 10, 11, 12, and 13 the carbonite was removed from the paper covering and gently pressed in to fill the full section of the end of the hole, the detonator being inserted and covered by the last portions of the charge. In experiment 15, the carbonite was used, in its paper cover, in the same manner as the other explosives.

In all cases the explosive was used alone, except in experiments 8 and 9, with blasting gelatine and coal or No. 2 securite, which were enclosed in a water cartridge and a damp chemically prepared flannel bag respectively. These appliances may be considered to represent a limited amount of tamping, and it would be interesting to ascertain definitely the lengths of stemming necessary to prevent the various explosives from igniting inflammable mixtures of air and gas, with or without the addition of coal dust.

Experiments 10, 11, and 12 did not produce explosion, and were at variance with the result of experiment 5, in which the mixture of gas and air was exploded.

It was suggested that some of the explosive used in experiment 4 had been left in the hole, and that its detonation had fired the gas. This theory was proved to be incorrect by experiment 13, in which 2 ounces of bellite in paper case, with detonator inserted, was placed at far end of shot hole, and "stemmed" with 8 ounces of loose carbonite.

Notwithstanding that the mixture of gas and air was tested repeatedly by a safety-lamp, it seems possible that it was not in every instance actually explosive. In experiment 10, the coal dust appeared to have been burnt, and this is confirmed by the clouds of smoke produced, possibly by its combustion. In experiment 12, there is a presumption from the appearance of a cloud of dust that it may have been ignited. It seems possible, although not certain, that flame was produced by the explosive in experiments 10 and 12, and ignited coal dust, and as there was no violent explosion the absence of an explosive mixture of gas and air may also be presumed.

From the appearances of the flames issuing in several of the experiments from the valve and end of the boiler, it seemed possible that the few minutes allowed in the experiments for the mixing of the gas and air was not sufficient. The flames in several instances appeared to be that of burning gas, mixed with little or no air.

If there was a large excess of air or of gas in the mixture at the parts traversed by the flame of the shot in any of the experiments, it would be readily recognised that an explosive might be considered as safe, whilst as a matter of fact, it had been exploded in an unexplosive mixture of air or of gas.

In future experiments the greatest care should be taken, in order to ensure that the gas and air should be uniformly mixed throughout the chamber.

It was recognised that explosive mixtures of gas and air might be ignited by the use of strong detonators, such as are commonly used with "high" explosives.

V.—Conclusions.

It may be concluded that all of the explosives tried in these experiments are capable of igniting fire-damp when fired unstemmed in a shot hole. It is probable that several of them possess some degree of safety when exploded in presence of gas under ordinary usage, that is to say, when exploded, even slightly stemmed, in shot holes.

The French Explosive Substances Commission recommend that the explosive should be very carefully stemmed at the bottom of the shot hole, which should be of sufficient depth. No empty space should be left either in front, behind, or on the side of the cartridge. Contact between the explosive and the Bickford fuze should be avoided, if the detonator be fired by that means. It would be, of course, prudent not to fire shots where explosive mixtures of fire-damp may be present.

Mr. W. Foggin said he would like to ask whether the experiments reported had been carried out at the instigation of the South Wales Institute, or were they merely trade experiments? Mr. Brown said that No. 13 experiment was made under the impression that No. 5 experiment had not been satisfactory, it being considered possible that some bellite had been left unexploded in the shot hole. It appeared that in three previous experiments only ten minutes had elapsed between each, but there was a twenty minutes' interval before the carbonite was fired—twice as long as in the other cases, and he thought the observers might have satisfied themselves in that time as to whether there was any bellite left or not. In the majority of cases the interval between the experiments averaged ten minutes. Did Mr. Brown observe during the experiments whether the boiler was thoroughly cleared from the gases generated during the previous experiments? It was stated in Nos. 5, 10, 11, and 12 experiments that "carbonite *without* paper cover" was tested. Was that carbonite simply thrown loosely into the hole, or was it stemmed in? Perhaps Mr. Brown would also explain how the detonator was fired in these experiments?

Mr. W. C. Blackett asked whether the 15 experiments were made without stemming throughout; if not, what was the nature of the stemming? and were any further experiments made as to the effects of different lengths of stemming on the various explosives?

Mr. Emerson Bainbridge said he had had the opportunity of being present at the experiments described by Mr. Brown, and believed that they were the most important experiments that had been made with high explosives. Mr. Brown properly remarked in his notes that no one would attempt to experiment with blown-out shots with the charge unstemmed in a pit. These experiments were, he believed, initiated by the manager of Messrs. George Insole & Sons' collieries with the

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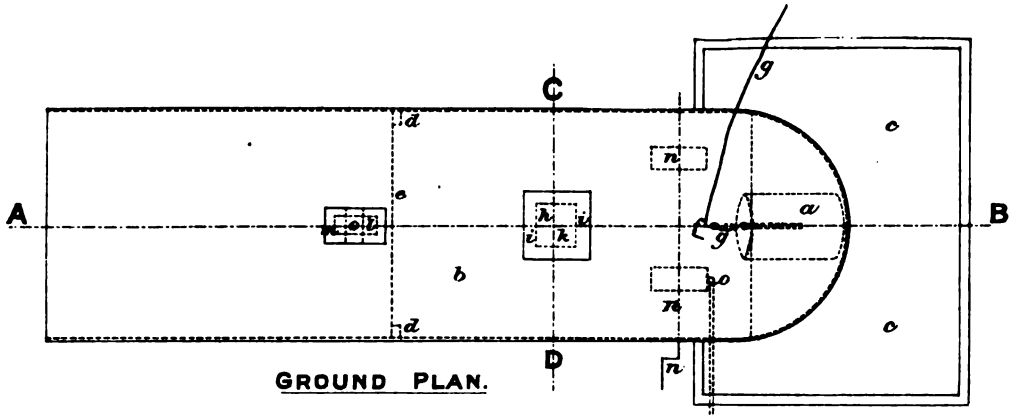
Vol. XI, 91

To illustrate Mr. M. Walton Brown's Paper on "Experiments with Explosives used in Mines."

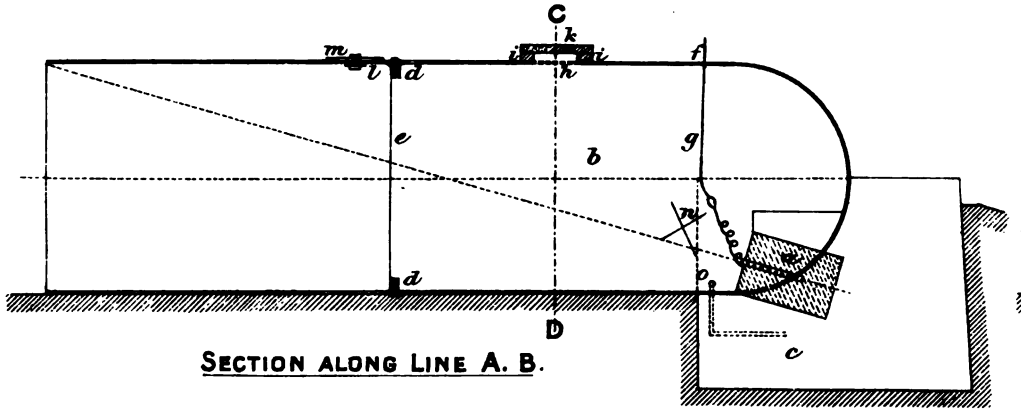
Apparatus at the Cymmer Collieries

used in the experiments on explosives on August 25, 1890.

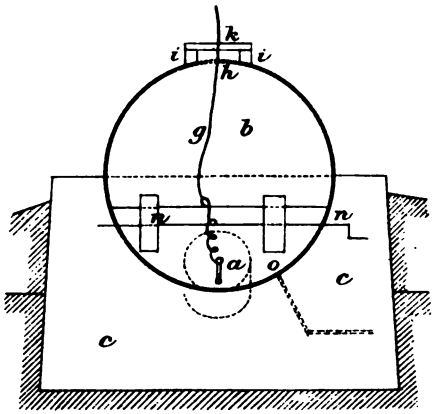
Scale of One Inch to Five Feet.



Ground Plan.



Section along Line A. B.



Cross Section on Line C. D.

And.W Reid Sons & Co. Lithos Newcastle

idea that one of the explosives was better than the others. The manager felt certain that carbonite would show no flame whatever; but when the first trial with it was made, much to the surprise of the manager, there was flame and explosion. He was unaware of the reason these experiments were made without stemming, but it was logical to consider that an explosive proved to be safe without stemming would be safe with it. The result in this instance, however—whether it was due or not to something foreign being in the hole, or to the explosive containing a proportion of nitro-glycerine different to that used under ordinary circumstances—was the production of flame and explosion, and this, he believed, was the first case of flame being shown by carbonite, even with an unstemmed shot. He thought that there were four points to be considered in selecting an explosive:—Absence of flame; the explosive when fired should not by its resulting gases endanger the health of the workmen; the quantity of work done in bringing down coal; and the relative cost of that mode of bringing down coal as compared with other means that are in use. These experiments, as they had heard, were with explosives—three especially—very much in use, carbonite, roburite, and securite. So far as they had gone, although interesting, and made with apparatus much more complete than had ever been used for similar experiments in this country, they were only a beginning. He hoped that if the Committee of this Institute, which had been formed for the purpose of experimenting on explosives, went on with its work immediately, they would arrange for a similar plant in the North of England, to work in conjunction with natural gas, or they might make some arrangement for transferring the whole of the plant from South Wales to the North of England, and try experiments with these explosives, under conditions similar to those found existing in a coal mine. There was one comment of Mr. Brown's, which he would like to ask that gentleman to reconsider. In No. 10 experiment it was remarked that the coal dust "appeared to have been been burnt." It seemed to be almost impossible that the charge in No. 10 experiment could have any relation to No. 9, but it was, at any rate, very curious, that with a quantity of only 8 ounces the coal was burnt, whilst another experiment with 12 ounces of the same explosive showed that the coal was unburnt. He hoped that the results of the experiments reported to-day would cause this Institute to encourage the Explosives Committee to get on with their work; there was nothing more important than to find a flameless explosive. Most engineers in the North, as they had in the Midland Counties, would have instances in which they were working without explosives, because they dare not use them, not having sufficient confidence in any. If experiments showed that they could rely on any of these explosives being perpetually and absolutely safe, they would be employed in many mines where they were not now in use.

The CHAIRMAN said that the great lesson of these experiments was that they wanted more of them; they were not sufficient, so far as they had gone, to enable one to form an opinion, and the whole question required investigation. They were

interesting as far as they went, but it was quite impossible to say from them that any explosive was safe or unsafe. His own impression hitherto had been that it was impossible to have an explosion without a flame; he was not a chemist, but if there were any chemists present he would be glad to have their opinion. An explosion consisted in the raising to a white heat, of a certain amount of combustible matter, sufficient to ignite the inflammable gas of the mine if it reached it. Another point he had noticed, and he did not know whether it was in connection with these experiments or some others made recently, the very low temperature at which gas became explosive when coal dust was present. The temperature at which coal dust took fire was, he believed, only about one-third that of gas, consequently, in addition to the fact that coal dust was explosive, the mixture became much more explosive with than without coal dust. It would be well for Mr. Brown to keep this in mind in treating this subject. These systems of trying explosives were excellent, and they of the Mining Institute were doing something in the same direction, but in order to have some little gauge of the matter himself he had instituted a test of his own. He had not gone underground, where he might be blown up, nor had he spent £200 or £300 in apparatus above ground, but he had simply gone to a quarry on a dark night and bored holes 2 or 3 feet deep into the face of the rock, and endeavouring to bring the circumstances as much as possible in agreement with those of the mine, had put in some stemming—as much as he thought the explosion would throw off. The hole being straight into the rock, the explosion must blow the stemming straight out, and was not in a position to blow the stone. It was therefore safe to stand within a few paces of the explosion to observe the effect. He had experimented in this manner with carbonite last week. These experiments had not been carried so far as to enable him to say anything of the results, but they were sufficient to enable him to judge of the value of an explosive, and he had come to the conclusion that they could not have any explosive absolutely without flame. They might have an explosive which was safer than powder—they were all safer than powder—but there was none absolutely safe. Even with the water-cartridge there was the risk of its bursting. In his own experience, with eight holes—tried in the presence of the representatives of the Dynamite Co.—no less than five of the cartridges burst before they were fired; consequently, if these were put into the hands of deputies who were perhaps not quite so careful in using them, very few of the explosions would take place under circumstances they would like. It became exceedingly problematical whether the use of explosives was desirable in ordinary practice, when their use was left to deputies and others. Under these circumstances he was of opinion that the more they could use coal-wedging machines the better for the coal, and if explosives must be used for stone let them ascertain which one was likely to give the best results. On this matter they must form their opinions from the experiments which were being made. Mr. Brown had gone very thoroughly into the subject, as he always did, and when that gentleman gave them his opinion they would be

safe in following his advice. It would also be interesting to know what explosives were now used at the various collieries; for his own part he was using roburite, and knew of nothing better, and others were using other kinds of explosives. It would be well to have their opinions on them, and to ascertain the present practice of the collieries in Durham and Northumberland.

Mr. M. WALTON BROWN, replying to the questions asked, said that, so far as he knew, the experiments were instigated by Messrs. George Insole & Sons and their manager. In experiments 5, 10, 11, and 12, the carbonite was placed loose in the hole and gently pushed to the end; and the detonator was covered by the last portions of the charge. As mentioned in the paper, the dust was allowed to accumulate during the first six experiments, except such as might have been blown out by the effects of the ignitions. The only cases in which stemming, or an appliance resembling it, might be said to have been used, were: in No. 8, where the blasting gelatine was enveloped in a water-cartridge, and in No. 9, where No. 2 securite was placed in a damp, chemically prepared flannel bag. These conditions might be assumed to represent a certain amount of stemming. In the other experiments nothing of the nature of stemming was used. It would be interesting to have a table of the effects of various lengths of stemming. With regard to experiments 9 and 10, in neither of which the explosive mixture appeared to be ignited, he might say that the coal dust appeared to have been burned in the latter experiment; it was swept out after No. 7, and appeared to have been burnt again in No. 10. In experiments 8 and 9 there was no ignition, and there was no cloud of dust; in No. 10 there was a cloud of dust, unaccompanied with a violent report as in the other experiments, but the smoke seemed to be due to the burnt coal. In No. 11 the dust was unburnt, and there was no cloud of dust or smoke; in No. 12 the dust appeared to be unburnt, but there was a cloud of dust and smoke. He was inclined to think that when the cloud of smoke and dust was seen the coal had been burnt, although it could not be detected.

Mr. W. FOGGIN did not think that Mr. Brown had quite understood one of his questions. In Nos. 5, 10, 11, and 12 experiments carbonite without paper covers was mentioned; what did "without paper cover" mean?

Mr. BROWN said that, in the case of Nos. 5, 10, 11, and 12 experiments the carbonite was unwrapped. It was taken out of the paper cover and pressed in with the detonator to the end of the hole. In experiment 13 it was put in the same way. There was only one experiment with carbonite in its paper cover, that was No. 15.

Mr. FOGGIN said his reason for being particular on these points was that during the last month or two he had made nearly 200 experiments with all the explosives in the market. His experience was that they all produced flame and exploded an explosive mixture. He used a chamber similar to that used in Wales, prepared specially for the purpose of his experiments. He found that all the explosives produced flame when fired without stemming. He was not previously aware that to get nearer the element of safety they had to unwrap the explosives and stem them

loose into the hole. It appeared to him that an explosive of that kind constituted its own stemming, and he would make trials under this condition. After arriving at the fact that none of these were safe by themselves without stemming, it was necessary to experiment with stemming, and commencing with ½ inch, and trying different lengths from ½ inch to 9 inches, he had arrived at a basis which satisfied him and at the same time surprised him, with regard to some of the explosives. He found that one or two of the so-called flameless explosives were very little removed from gunpowder. Could Mr. Brown say whether the explosives used in these experiments were supplied from the makers direct or taken from the ordinary supplies of a colliery using the explosive?

Mr. HODGSON asked if he was correct in understanding that in No. 10 experiment the coal dust was burnt and no flame seen? He would like to know if Mr. Brown always took it as a test that flame must be seen?

Mr. W. C. BLACKETT said he had the pleasure of witnessing some of Mr. Foggin's experiments, and considered that they proved that all the explosives which were tried, and which included those tried in Wales, were unsafe when unstemmed. It appeared that safety began to show itself when a certain amount of stemming was used, this length forming a sort of inverse ratio of safety. It was hardly fair to include in a list of this kind Nos. 8 and 9 as not being stemmed; Mr. Brown had, however, very fairly drawn attention to it, though it might mislead some who were not present at the discussion. Mr. Foggin's experiments seemed to suggest that water stemming might not render the explosive any safer than an equal amount of dry stemming. Another point which he thought might be carefully attended to by the experimenters in this enquiry was the effect of accidental friction in producing flame, which, without consideration, might be attributed to the explosive itself. He could imagine many cases of experiment where small particles of almost anything set in motion by the enormous force of the explosion—a force they were not familiar with in that respect—and becoming heated by friction, might inflame a mixture of fire-damp and dust, and the explosive be blamed when it had nothing directly to do with it. After Mr. Foggin's experiments, he (Mr. Blackett) was allowed to take home some of the explosives used. He took them into the pit, and placed them in the hands of some of the men accustomed to using roburite. He found that some of the new explosives were liked much better than roburite. In the case of ammonite the fumes were less offensive to the men, who were accustomed to roburite, and the power was slightly greater. Carbonite was another of the explosives tried; it was liked as well as roburite, but the men came to the conclusion that it was slightly weaker though the fumes were less objectionable. He had the report of these men—stonemen—in his possession; they had not the slightest idea what the new explosives were; these were simply given to them to try, and they gave an opinion without any prejudice whatever.

The CHAIRMAN asked Mr. Foggin as to how his experiments were made?

Mr. FOGGIN—Exactly the same as those described by Mr. Brown.

Prof. MERIVALE suggested that Mr. Foggin should define more clearly how he made the experiments. Was natural gas or coal gas used?

Mr. FOGGIN said that coal gas was used. They had a blower of natural gas at the colliery, but unfortunately it fluctuated so very much, and to have carried out such a series of experiments as he had made would have occupied twelve months if he had waited for the natural gas; he therefore procured a supply of coal gas.

Prof. MERIVALE—Then, so far as you know, it is only in the case of coal gas that these explosives fire?

Mr. FOGGIN—Yes.

Mr. BROWN said, from the appearance of the flame in several cases, he was of opinion that the few minutes allowed in these experiments were not sufficient to ensure the gas being thoroughly mixed with the air. The flames seen in several cases were probably the burning gas. The whole of the explosives used in the experiments (so he had been informed) were supplied by colliery managers using them, and in the case of carbonite he presumed it was taken from the ordinary supply used at Cymmer Colliery. Mr. Hodgson asked if coal dust was burnt and no flame seen. In his (Mr. Brown's) opinion they could not depend upon their eyes as to seeing flames, and should therefore resort to some chemical means, or, as was suggested by No. 9, to the use of small animals, or they might resort to sensitive photographic plates. The latter could be used in the mine in a case covered by a slide fitted with openings, say ½ inch diameter, and exposed to the flame of the shot. If the paper exposed through the openings was fogged on development in the slightest degree, it would show that the explosion had produced a photogenic flame; and if the space outside of the exposed openings was clear when developed, it would prove more certainly that the fog had been produced entirely by the flame of the explosive.

The CHAIRMAN said the discussion would be adjourned until Mr. Brown's paper was printed and issued to the members, when he hoped they would be prepared with a little more information. He moved a hearty vote of thanks to Mr. Brown for his valuable paper, and he suggested that they should also include Mr. Bainbridge, who had come from Sheffield, and Mr. Foggin.

The vote of thanks was carried with acclamation.

DISCUSSION ON MR. JOHN TAYLOR'S PAPER ON "ELSOM'S IMPROVED METHOD OF LIGHTING MINERS' SAFETY-LAMPS WHILE LOCKED."

The SECRETARY stated that Mr. John Taylor was to have described "Elsom's Patent for Lighting Miners' Safety-Lamps when Locked;" that gentleman, however, who was to have been in Newcastle at twelve o'clock had not yet arrived.

Mr. BAINBRIDGE said the lamp and apparatus was the same as that exhibited at the Nottingham meeting. By means of a sketch on the blackboard, he explained the principle of the invention. A rod is fitted into the lamp bottom, capable of holding two short matches, which, when required, can be turned round, one at a time towards a roughened plate attached to the side of the wick tube, and ignited on the roughened surface, by moving the rod upwards and downwards. It was so arranged that the lamp could be relit twice. At the Nottingham meeting, however, it was considered undesirable in fiery mines that a man should be enabled to relight his lamp.

The meeting then terminated.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,

DECEMBER 13TH, 1890.

MR. GEORGE BAKER FORSTER, PAST-PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last meeting.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. James Burn, Mechanical Engineer, etc., 28, Fawcett Street, Sunderland.

Mr. William Rochester, Colliery Manager, River View, Blaydon-upon-Tyne.

Mr. Francis H. Spencer, Mining Engineer, Robinson Gold Mining Company, Witwatersrand, South Africa.

Mr. Hugh Waddle, Mechanical Engineer, Llanmore Iron Works, Llanelly, South Wales.

ASSOCIATE—

Mr. William Stephenson, Under Manager, Garesfield Colliery, Lintz Green.

The following gentlemen were nominated for election:—

MEMBER—

Mr. Louis Irving Seymour, Mechanical Engineer, Chief Mechanical Engineer, De Beers Consolidated Mines, Limited, Kimberley, South Africa.

STUDENTS—

Mr. Nicholas John Bitzos, Mining Apprentice, Broomhill Colliery, Acklington.

Mr. George Chrisostom Zumbuloglon, Mining Apprentice, Broomhill Colliery, Acklington.

Mr. DAVID BURNS, C.E., F.G.S., read the following paper on "The Bending of Beds near Veins":—

ON THE BENDING OF BEDS NEAR VEINS.

By David Burns, C.E., F.G.S.

The origin of mineral veins, and the sources and method of arrangement of their contents, are still subjects shrouded in considerable obscurity. The present paper is an effort to glean from the strata in which veins occur some fragments of knowledge of the physical conditions under which they were formed. When veins traverse beds of varying resistance and of moderate thickness, as they frequently do in the North of England, the strata are thrust upwards or downwards, more or less, on one or both sides, as they approach the vein, and especially in its immediate vicinity. The well-known alternations of the north country Lead-measures allow such disturbances to be accurately noted, although, unfortunately, not being of commercial importance, there is not as much exact knowledge of the behaviour of strata, near to even well-known veins, as might be desirable; but there is sufficient for a general treatment of the subject, and if once its importance is fully appreciated, accurate observations will multiply.

Fig. 1, Plate VI., is an instance of disturbance of a very simple character. The strata are only disturbed very locally, and that along the line of the fault. There has been upward fluid pressure of a very contracted but intense character, which has been able to force itself through the strata and so to escape. Such a vein is an elongated crater, and the mineral left in it but the sweepings of a chimney, so to speak, that once reeked with riches. The formation of the arch might give a little relief laterally to subsiding strata, and might be, to some extent, a wrinkle caused by increasing horizontal thrust. Nor is this a condition to be ignored. If a stratum be taken 100 miles long, lying perfectly horizontal, and suppose it to be depressed one mile—a small change of level in comparison with those frequently assumed by geologists—and the radius of the earth being reckoned at 3,962 miles, then 3,962 miles : 3,961 miles :: 100 miles : 99·974 miles; that is, this length of strata will have ·026 miles or 45¼ yards less room in which to lie, and it must, therefore, be inclined at an angle of 1° 17′, or be crumpled up to the extent of 45¼ yards per 100 miles. There can be little doubt that the shrinking of the earth's radius, and the dip of sedimentary strata, are mutually accommodating conditions. If an accurate horizontal section of any particular sedimentary bed in, say, the Carboniferous formation, could be made in any direct line for 100 miles, and the total length of the pieces so measured were taken, then their sum would exceed 100 miles, in the same proportion as the diameter of the earth, at the close of the Carboniferous period, exceeded its present diameter. This estimate would probably be under the truth, owing to increasing density of the rock with time and pressure, and, it might be, to the secular cooling of even the most superficial strata of the earth, since Carboniferous times.

Fig. 2, Plate VI., represents the cross section of a fault, showing what will usually be considered the normal hade and the usual flexure of the strata. The

foundations of B are supposed to have given way somehow while A stood fast, and so a break occurred, and the B section slid down along the face of the A section, dragging down, by sheer friction, the edges of the strata *a*, *b*, *c*, on the A side, and dragging up, by the same agency, those strata on the B side. Such is the aspect most frequently presented by faults, and such is the explanation put forth. Now, if the strata B were free to move horizontally in the direction C, this explanation might be considered fairly satisfactory; but they are not. As already seen, the strata, by getting nearer the earth's centre, get into more contracted quarters, but, ignoring this circumstance, as being of little effect in the case of faults of moderate throw, the hade makes a vertical motion of the strata B impossible. Indeed, if B were to fall down vertically, simply by reason of its weight, the hade of the fault would be instantly reversed, and a fault like that shown in Fig. 5, Plate VI., would be the consequence, the rising beds in A, or the falling beds in B, finding relief from horizontal thrust by sliding on each other in the manner indicated, it will be noticed that each stratum *a*, *b*, and *c* overlaps its continuation on the other side of the fault, that is, *a* and *a'*, *b* and *b'*, *c* and *c'* severally overlap each other. But, instead of supposing B to fall down vertically, let us suppose it continues to be supported at the point C (Fig. 2, Plate VI.). A is stationary as before, and now, if the foundations of B give way, the strata B will fall down, revolving roughly round a centre, C, and tracing arcs to which the fault will be tangential. According to this view, the mass B would, at the time the fault was forming, partake of the nature of a floating body, and of the descending ram of an hydraulic engine. The yielding fluid under B need not have escaped through the fault shown. It may have been forced from one underground chamber to another, and hence to the day. The writer has frequently found, and believes it to be a rule to which there are but few exceptions, that whereas on one side of a considerable fault the strata are pretty sound, on the other side they are broken up by minor and often parallel faults, and otherwise bent and distorted. The side so broken is the one that has tottered on the abyss of chaos, and the one within which metalliferous riches may be most confidently expected.

But although the hade shown in Fig. 2, Plate VI., is general, it is not the invariable rule, as the hade is sometimes observed reversed as in Fig. 5, Plate VI. Indeed, the writer believes the latter figure represents more correctly than any of the others a fault pure and simple, namely, a dislocation between two neighbouring areas, caused by a difference of upward pressure in these areas giving rise to a relatively vertical motion, as influenced by the disturbing forces, and a relatively horizontal motion, to make room for the fault, and it might be horizontal thrust experienced independent of the disturbance which gave rise to the fault.

But there is still another variety of vein which, as far as I am aware, has been a puzzle to geologists up to the present time. It is shown in Fig. 3, Plate VI. The peculiarity is that on the downthrow side the beds dip to the fault, and on the upthrow side rise to the fault. This clearly could not be the result of friction, for as has been already seen, the rubbing causes flexures in the opposite directions. It has been undeniably due to intense local pressure. Let us suppose a crystalline

stratum as *c* in Fig. 4, Plate VI., and that it is assailed from below by intense fluid pressure. This fluid ultimately breaks *c* across, and the probability is that the fracture will not be quite vertical. Let us suppose it takes the direction of the line *o m*. The fluid then insinuates itself into the crack, and as all fluid pressure is normal to the surface on which it acts, forces, represented by the arrows, come into play, and as a result the stratum on the side A is thrust up, and on B it is thrust down into the form shown by the dotted lines in the figure. If now we suppose the crystalline bed *c* to be followed by a thinly laminated bed of shale (*b*) this would naturally tear in the direction of pressure put upon it by the upward rising edge of *c*, namely, in the line *m s*, and each lamina would communicate its pressure to the next, a little to the left of the point at which it received it. Probably at this stage the shale on the B side would also be thrust upwards against the next resisting bed; but no sooner would the fluid reach the next strong and resisting stratum *a* than a fracture would be created in somewhat the direction *m o*, and the same sequence of events would be repeated, *a* would now thrust down the soft and yielding shale, thereby breaking it up and forming the "donk," which now characterises veins within it, and going far to close the vein at this point.

The succession of strata put in the diagrams is that most usual in the Lead-measures of the north, and it explains several oft-observed features in the veins therein.

If this explanation be a true one it becomes no mystery why veins sometimes take a run along the top of a hard bed, as along the top of *c* towards B, as the crushing down of *c* would almost invite it in that direction. But probably the rush of the fluid through these strata was nearly instantaneous, and in the majority of cases the flow would continue in the main in the direction once instituted.

It is found in these veins that they are nearest the vertical in the hard beds, as limestone and sandstone, and nearest the horizontal in the shales. This is what would naturally occur in a vein as supposed. In repeated attempts to shear sealing-wax by applying, as it were, force upwards at A and downwards at B, the writer found that in at least two-thirds of the cases the fracture inclined slightly in the direction of *m o*, thus tending to confirm this hypothesis, and refute the theory that the hade and throw of veins is due to a direct thrust upwards or downwards on either hand. The pressure on the walls of these veins would practically be uniform throughout, and hence the shales would be subjected to the same pressure as the limestones. But it would be the more crystalline rocks that would present the distinct sloping fracture necessary to give rise to the twisting action, and hence there would be a tendency for each hard bed to crush back the yielding shale below it, and, to a certain extent, close the vein at that point, the fluid contents readily accommodating themselves, even when under enormous pressure, to the various resistances of the different strata. This is one reason at least why in the limestone we find the veins widest and the minerals most plentiful, and in the shales the veins narrowest and poorest. Whereas the fault with the reversed hade is the true fault, so the vein in the strata with reversed bends is the truest mineral vein.

The writer has noticed in plotting horizontal sections that much of the reported throw of veins was compensated for by the flexures in the strata, and that, taking two points some distance away from the vein on either side, the strata were in the same plane, either level or that of the ordinary dip of the country, as they would have been had there been no veins at all.

That molten or gaseous minerals have escaped to be condensed in the air, or in an overlying ocean, seems to be proved by the deposits worked at Commern in Rhenish Prussia, and at other points in Germany and elsewhere.

The presence of galena and other mineral matter disseminated through the rocks has been considered evidence that veins have derived their contents by infiltration from the country rock, but it may with equal probability be taken as evidence of the escape of mineral matter at the time of the formation of some other vein and of the rocks in question.

In the thick limestones of the North of England horizontal layers of mineral occasionally lie alongside of the veins, and are known as "flats." These would most naturally occur on the downthrow side of such veins as have the reversed flexure, as on that side the partings between the posts of the limestone would be opened and more likely to catch the upward rush of mineral.

The peculiar value of the phenomena presented in Fig. 3, Plate VI., is that there is no ambiguity as to the cause of the bending of the strata. In most speculations as to the origin of veins, we have generally two or more theories which account with almost equal probability for them. In this case, however, there is a series of veins that were formed by a fluid of some kind bursting upward under immense pressure, and which could not have been formed in any other way. There may have been in many cases subsequent dislocations along this line of fracture altering the throw and complicating the phenomena, but where the flexure shown in Fig. 3, Plate VI., now exists, or can be shown to have existed, the vein has been formed by the upward intrusion through the strata of some fluid substance under enormous pressure. Whether the fluid was a gas or a liquid the writer is aware of no evidence to show. But one or other, or both, must have been there. Moreover, these fluids have not been free to rush to the outer air or ocean as they probably were in the cases illustrated by Fig. 1, Plate VI., but have been confined so long as to distort the strata, as shown in Fig. 3, Plate VI., and seal them in that position. They may have escaped later and been replaced by other mineral matter. But since there is conclusive evidence of foreign matter having been thrust up through the strata, and that there is found in these veins such matter distributed very much as would be expected from the causes shown, it is difficult to avoid the conclusion that in these veins, at least, the theory of sublimation is absolutely proved.

Professor LEBOUR said there was one point on which he would like to ask Mr. Burns's opinion; it was in regard to the dip of beds towards "necks" or "traps." The same thing occurred in the case of whin dykes, the dip being towards them, and

not away from them as one might have imagined if the veins had been formed by the rising of liquid matter from below. This was not the same thing as Mr. Burns referred to; he mentioned veins filled in a different manner, but this applied to faults filled with igneous rocks, and in that case it was imagined that the bending towards the igneous matter was caused by the dragging down, or cooling, or probably after the intrusion of the matter. It was interesting to point out that the first time this was noticed in print was by Mr. Arthur Balfour, in the *Geological Magazine*.

Mr. D. BURNS said he was not previously aware of this phenomenon; he had never noticed it, and was rather at a loss to account for it. It occurred to him, on the spur of the moment, that it might have been caused by the upheaval of the whole country, so to speak, the stratified beds only being upheaved while the others remained stationary. If the whole country was being raised up, a trap resting on a foundation which was not raised at all might cause this bending.

Mr. THOS. BELL (H.M. Inspector of Mines)—In what part of the country do you find that dipping of the seams?

Professor LEBOUR said the particular neck he was speaking of was on the Haddingtonshire coast near Dunbar; but he had seen the phenomenon at whin dykes in a few places in Northumberland. For instance, in the three dykes near the North Tyne up the Borswick Burn it is shown very distinctly.

Mr. THOS. BELL said he had traced the whin dyke from Shotton Colliery as far as Middleton-in-Teesdale, and he had not found anything of the kind indicated by Prof. Lebour. He had worked up to it in perhaps a dozen places at Thornley, Cassop, Shincliffe, and Houghall, and in all cases the beds were perfectly level.

Mr. BAILES said that at North Fenham Colliery there was a distinct dip of the beds on each side of the whin dyke, and this dip to the dyke was very distinctly visible.

The CHAIRMAN proposed a vote of thanks to Mr. Burns for his very interesting paper. Without altogether agreeing with all the views expressed, and which were no doubt perfectly correct as regards the lead-mining districts, he thought they must look in the coal-mining district for a different explanation. As a general rule their faults were like Fig. 3 on Plate VI., rising to a dip trouble and dipping to a rise trouble, and as the faults were sometimes "risers" and sometimes "dippers," they must look for some more general disturbance than a fluid acting in the fissure.

Mr. J. B. SIMPSON seconded the vote of thanks, and it was cordially adopted.

Mr. D. BURNS acknowledged the compliment, and thanked the members for the very patient hearing which they had given him. He was sorry the paper did not cover the whole of the ground; there were still many points to be considered.

The following paper by Mr. Edward Halse on "Some Banket Deposits of the Gold Coast, West Africa," was taken as read :—

To illustrate Mr. David Burns' paper "On the bending of Beds near Veins."

FIG. 1.

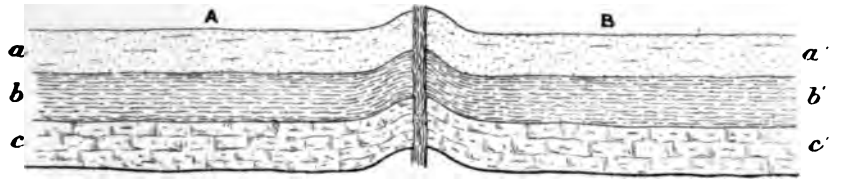


FIG. 2.

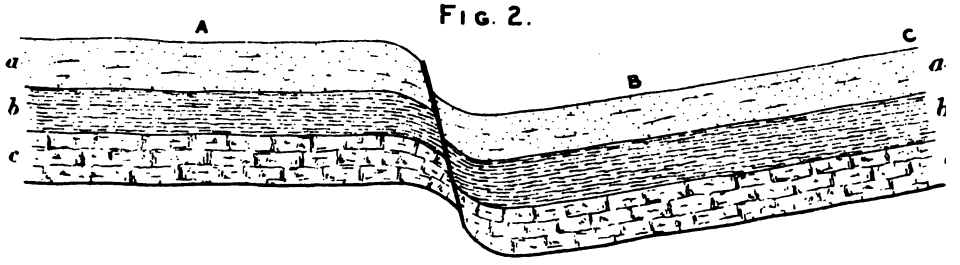


FIG. 3.

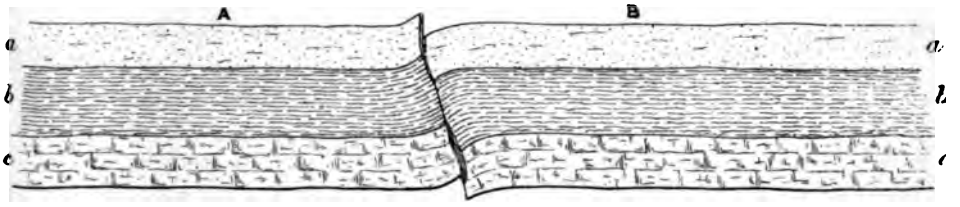


FIG. 4.

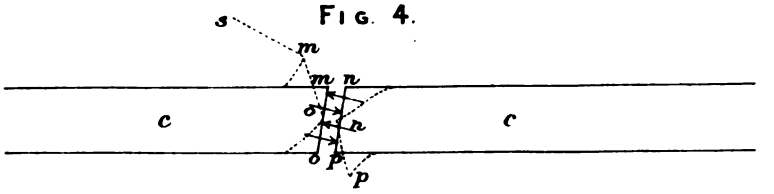
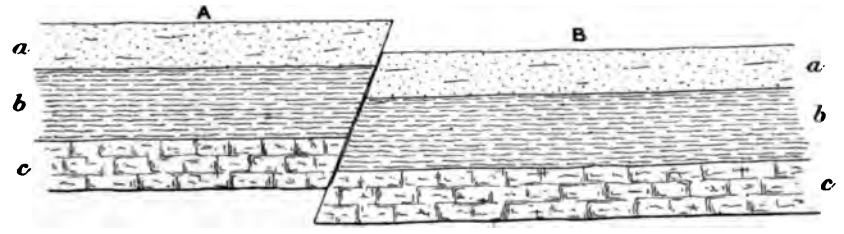


FIG. 5.



SOME BANKET DEPOSITS OF THE GOLD COAST, WEST AFRICA.

By Edward Halse, A.R.S.M.

The auriferous conglomerate or banket deposits, discovered in South Africa only a few years ago, are by this time fairly well known,* while concerning those of West Africa, which have most probably been worked by the natives for about two centuries, little has been written,† and in this paper an account will be given of several banket deposits which the writer has lately had an opportunity of examining on the Gold Coast.

The word banket (in Dutch = sweetmeats, hence almond toffy) can, strictly speaking, be applied to any conglomerate, whether auriferous or not, and is practically equivalent to "pudding-stone," "cement" (Australia), and "blue lead" (California). Mr. Brough Smyth describes *cement* as "a stratum of very ferruginous conglomerate, composed of rounded pebbles of quartz, angular fragments of the same rock, and small pieces of schist,"‡ which, in some districts, is highly auriferous, and worked at a profit. But the *gisement* of the banket reefs is entirely different from that of the so-called cement or blue lead, for whereas the former, usually of primary age,§ are found interstratified with other contemporaneous rocks of a quartzitic character the latter belongs to "deep lead" or ancient Tertiary alluvial deposits, filling valleys and hollows or "gutters," preserved from destruction by layers of basalt, and usually lying unconformably on the much older bed-rock. The cement is found below the wash-dirt, "overlying the bed-rock—in some places touching it, and in others a few inches or a few feet above it" (Brough Smyth). Cement has also been found to occur in recent alluvial deposits.

The term *banket-reef* is misleading, as it is suggestive of a true fissure-vein; it would be better to call that class of deposit a banket bed or seam. Knochenhauer says—"Die de Kaap Riffs sind Lagergänge,"‖ and, indeed, the equivalent *bedded-vein* is more applicable to the quartzite reefs of De Kaap, and bankets of Witwatersrand than to the conglomerates of the Gold Coast; for, as we shall see the gold of the former has been deposited subsequently to, and of the latter contemporaneously with, the bed in which it occurs.

* See C. L. Alford, F.G.S., in the *Mining Journal*, Oct. 5, 1889, republished in pamphlet form; A. R. Sawyer, *Trans. N. Staff. Inst. Min. and Mechl. Engrs.*, Vol. X.; the *Engineering and Mining Journal*, E. B. Dorsey, July 20, 1889, J. S. Curtis, Feb. 5, 1890; B. Knochenhauer, *Die Goldfelder im Transvaal*, Berlin, 1890. For the conglomerates of the De Kaap districts, see C. L. Alford, *Mining Journal*, April 27, 1889; W. H. Furlonge, *Trans. Am. Inst. Min. Engrs.*, 1890 (Abstract in *Engineering and Mining Journal*, March 8, 1890).

† See Skertchly; *Journ. Roy. Geogr. Soc.*, Vol. 48, pp. 274-283; Cameron, "The Gold Fields of West Africa," and Burton, "Gold on the Gold Coast," in *Journ. Soc. Arts*, Vol. 30, 1882, also *op. cit.* below; E. McCarthy, *Mining Journal*, July 1, 1882, and P. Dahse in *Deutsche Geographische Blätter*, 1882.

‡ *The Gold Fields and Mineral Resources of Victoria*, 1869, pp. 352-354; see also J. Arthur Phillips, F.R.S., *A Treatise on Ore Deposits*, 1884, pp. 458-9, and Lock's two volumes on *Gold*. Compare C. Waldeyer in R. W. Raymond's *Mining Industry . . . West of the Rocky Mountains*, 1874, chap. xi.

§ Auriferous conglomerate of Cambrian age is found in the Black Hills, Dakota, of Siluro-Devonian age in New South Wales, of Devonian age at Witwatersrand, of Carboniferous age at Besseges, in Languedoc, in New South Wales, Tasmania, and New Zealand, and of Permian age in New South Wales, while "gold has been recently discovered in the marine conglomerate and shale beds, which are believed to be of Cretaceous age, and which rest upon the flanks of the Silurian, Devonian, and granite formations in the Mount Brown or Albert Gold Fields." *Catalogue of Exhibition, New South Wales Court*, Mining and Metallurgical Exhibition, Crystal Palace, 1890.

‖ *Op. cit.*

The chief mines of the Gold Coast are situated in the Wassaw country, between 4° 50′ to 5° 30′ N. lat. and 1° 50′ to 2° 25′ W. long., comparatively near the banks of the Ancobra River, which, running in a general north and south direction, falls into the sea a little west of Axim. Leaving recent alluvial deposits out of account, the mineral deposits of the district may be divided into two classes:—

(1) Gold quartz fissure-veins traversing schist, and

(2) Bedded alluvial deposits enclosed in sandstone.

The latter are said to lie unconformably on the former (E. McCarthy), and are, therefore, of more recent date, and while (1), as a rule, occur west of the Ancobra, (2) are found to the east of that river. Among the exceptions are the auriferous quartz vein, marked by M. Bonnat,* on the east bank, a little north of Tumento, and those existing on the west bank of Prince's River,† and which, according to a French map, published in 1750, was formerly called "Gold River" by the Portuguese. In point of fact, the whole country is so densely covered with bush that hitherto comparatively few mines have been discovered, and for the same reason the geology of the country has still to be worked out.

The mines about to be described are from 41 to 56 statute miles in an air-line from Axim,‡ and, travelling by river and bush, 60 miles must be traversed to reach the centre of the group. Proceeding in a hammock to the mouth of the Ancobra, one ascends the river in a steam launch, canoe, or surf-boat as far as Tumento on the left bank, and thence by hammock along a bush track to the mines, the chief of which are about 22 miles from the river side. The writer left Axim in a surf-boat, manned by 14 Kroomen using paddles, and, crossing the bar, arrived at Bonsa station on the Bonsa River, in a little over two days' time, travelling mostly by moonlight, and being often lulled to sleep by the peculiar and monotonous chanting of the Kroomen. Soon after ascending the river, and having passed the dense mangrove swamps, one is struck by the great height of some of the trees, and by the marvellous wealth of tropical vegetation lining the banks of the river. At night, when the highest tree-tops are obscured in white mist, and the moon casts but a pale and sickly light over all, the scene is weird in the extreme, and is not likely to fade soon from the memory of the beholder.

TOPOGRAPHY.

Commander Cameron's map of this region shows a number of hills from about 1,000 yards to 6 miles in length, and running, most of them, a little east of true north. The hills are crossed at right angles by small valleys, the bottoms of which are of a little higher elevation than the main north and south valleys—the gradient of the latter towards the sea-coast is only 2½ feet to the mile, and yet hydraulicking has been recommended for this district! The whole country is covered by forest and

* Carte des Concessions de "The African Gold Coast Company," 1879.

† *To the Gold Coast for Gold*, by R. F. Burton and V. L. Cameron, 2 vols., 1883. The map of Messrs. Walker and Bonson having the claims of the African Consolidated Mines, Ld., marked on it, seems to be mainly taken from Cameron's map in the above book. Dahse's map is taken from the above and other sources.

‡ From Chama to Taquah is only 28 miles in an air-line; the Government is now making a good road by that route.

dense bush. Both the auriferous veins and the banket seams, as a rule, follow the direction of the hills. Plate VII. is a general map of the district, after Dahse; Plate VIII., after Messrs. Walker and Bonson, shows the relative positions of the banket mines, and the direction of the hills on which they are situated. The chief seams are marked down on both maps, from data taken from various sources.

TAQUAH MINE.

The present workings, from surveys made by the writer, are shown in plan on Plate IX., and in section on Plate X. The deposit strikes N. 47° E. (magn., 1890), or N. 32° 20′ E. (true). It has a distinct bend, however, the southern portion striking N. 13° E. (magn.), or N. 1° 40′ W. (true). The deposit appears to form an acute angle with the average run of the hill, which is 260 feet above sea-level. The main bed appears to form a distinct saddle above the new tunnel (Plate X.); and, although a quartz vein is seen in places along the huckle, which might be taken for a saddle joint, the seam in the two levels would really appear to form one main seam, divided by a "horse" of sandstone rock, the general dip being north-westerly. Unfortunately, the older lower workings in the Verillon tunnel cannot now be surveyed, owing to falls of ground, etc. One wing of the saddle-bend dips N.W. 31° and the other S.E. 49°, gradually lessening towards the lower portion until it becomes horizontal.

The seam has been worked by shafts driven by the natives for a long distance N.E. and S.W. of the present workings. Some of the shafts are covered by bush, some have fallen in, and the remainder are so small, and the workings so narrow, that it is very arduous work to examine them, and for these reasons an accurate plan of the whole mine does not exist. The Taquah Seam, at first sight, does not look like a banket deposit; however, a minute examination seems to show that it is really a very fine conglomerate, arranged in layers, merging occasionally into coarse conglomerate of the ordinary type on the one hand, and into moderately fine sandstone on the other. For the most part it consists of more or less rounded grains of quartz, from coarse to fine, of titaniferous iron ore in layers and in scattered grains, and of extremely thin plates of silvery-white talc. The bed is thickly strewn with the latter and has little cohesion, crumbling to pieces with very slight pressure, but in other respects resembles Brazilian *itacolumite*.* The fragments are very gritty to the touch—carbonate of lime and clay, if present at all, are there in small quantities only. The seam may roughly be said to consist of layers of titaniferous iron ore, carrying free gold alternating with layers of practically non-auriferous talcose sandstone. The width of the layers varies, as well as that of the whole seam; in the portion now being worked, close to the new tunnel, the width has been proved to be 18 feet. Sometimes the titaniferous iron ore occurs in solid layers, several inches thick, and sometimes well crystallized in quartz, filling cross joints.

* "*Itacolumite* is a friable sandstone, consisting mainly of quartz sand, but containing talc or mica, and sometimes also possessing a certain amount of flexibility when in thin laminæ." J. Arthur Phillips, *op. cit.*, p. 613; also W. J. Henwood, *Trans. R. Geol. Soc. Cornw.*, vol. viii., p. 172. When specular iron ore replaces the talc or mica, it is termed *itabirite*.

The bottom portion of the bed is from 6 to 12 inches thick, and containing much titaniferous iron, has the most free gold, and it is this portion alone that is worked by the native Fantis. They sink vertically a small round shaft, or rather chimney (locally termed *tobon*), about 2½ feet in diameter, to the richest part of the seam. The shafts are nowhere deeper than 100 feet, as the natives cannot cope with the water below that depth. Having cut the seam, they work it away in a very irregular manner. After driving horizontally a few feet, they sink a little on the dip, working the seam away for several yards on either side as they go down; they may then drive again for a short distance along the bed, sink a few yards deeper, and so on. The above was the method which had been adopted in some old workings examined by the writer. In places the workings are so narrow that one has to wriggle up and down the slope of the seam on all fours. The exertion is terrible, and when, as sometimes happens, one comes in contact with a run of driver ants, the situation is anything but a pleasant one. It can be readily understood that in workings measuring only 14 inches wide there is no room to swing a pick; the natives work out the seam with hammer and chisel, carrying the mineral to the surface in earthen pots or calabashes up a bamboo ladder about 5 inches wide. In sinking they use, according to Skertchly,* a small iron hoe 2 inches broad and from 4 to 6 inches long, with which they scrape the sandy earth into a calabash; but McCarthy says a method of "fire-setting" is also employed. It was the custom to allow the natives thus to work out portions of the seam on tribute, the company providing the tools and allowing the natives half the ore raised to bank. This method was merely an imitation of the old native custom of paying half the ore gotten to the kings or chiefs,† but, as it gives free scope to extensive fraud, it has recently been abandoned. The whole bulk of the seam—the best portion being from 2 to 2½ feet thick—is sent to the stamps, and a partial hand-picking takes place there. The ore yields at the mill from 5 to 7 dwts. of gold to the ton. It is easy to crush, and the gold, being entirely free, is readily caught on the plates; some, however, in very fine powder ("flour gold"), is only partially caught on the lower amalgamated plates and on the blanketing.

It will be seen from the section (Plate X.) that another and upper seam has been explored, but the main seam is the only one now being worked. The upper seam, from 2 to 3 feet thick, is of similar structure, but it contains less gold; and the lower portion of it—said to be rich—is at present under water. A sample taken from the best part of the main seam, assayed 9 dwts. 18 grains; while one showing titaniferous iron ore in layers in sandstone gave 7 dwts. 19 grains, and one showing thick layers of titaniferous ore gave 13 dwts. 16 grains of gold to the ton of 20 cwts. (Dr. George Tate); hence the assays confirm the panning results, that where there is most black sand there is most gold; the former is in this district an almost certain indication of the latter.

* Mungo Park describes in his book of Travels the method of digging deep pits employed by the Mandingoes. They used small spades or corn-hoes for this purpose, and drew the earth up in calabashes. Strata of fine reddish sand with small black specks (? iron sand) were usually found to be auriferous.

† This custom is alluded to in an anonymous work published in 1665, and quoted below. This little book contains an interesting and fairly accurate account of the native customs, of the weights used in the sale of gold, of the traffic with the Hollanders, and of early voyages to the Gold Coast.

The old shaft should be sunk to the main seam, which will be met with at a depth of from 60 to 70 feet vertical. By this means a further 200 feet of the main and about 150 feet of the upper seam will be laid open on the dip, and very much better results may be expected than hitherto.

Abosso Mine.

This is six miles north of Taquah village, and is one of the most promising mines on the Gold Coast.

Plate XI. is a plan, and Plate XII. a section of the present workings in this mine, from surveys by the writer. The seam runs N. 53° E. (magn. 1890), or N. 38° 40′ E. (true), with an average dip of 35° to the N.W., and has been proved for about 700 feet in length. The main hill here trends N. 40° E. (true), and may be regarded as a continuation of the Taquah range; hence the seam is practically parallel with the average run of the main hill, the top of which is 310 feet above sea-level, and along the western slope of which it crops out. This is undoubtedly a banket deposit, although here and there portions of the seam show a structure similar to that of the Taquah deposit. The strike and dip are very uniform, the roof or hanging-wall is extremely well-defined, but the thickness varies considerably. At the south-west end the seam consists of a single layer of rich conglomerate 2 feet in width. Further north, or 80 yards from this point, the thickness is 18 feet; the upper portion, however, is very poor in gold. At one place where the seam is very rich the section shown, commencing at the roof, was as follows:—2½ feet of pale sandstone containing black streaks (titaniferous), poor in gold, 6 inches of auriferous conglomerate, 9 inches of sandstone and layers of titaniferous iron with gold, 9 inches of rich conglomerate, 12 inches of sandstone rich in titaniferous iron ore and free gold forming the bottom layer; total thickness = 5¼ feet. The true roof of the seam is a hard quartzose rock (grit) 25 feet thick, above which is a thick bed of talcose sandstone similar to that at Taquah, and upon this again lies a red marly rock (coloured by oxide of iron) proved for many yards in thickness. In cross-cutting through the latter, which is soft, one meets with streaks which give a good colour of gold in the bowl. Immediately below the seam there is usually a layer of soft clay, but talcose sandstone forms the true floor or footwall. A sample of the lowermost layer of conglomerate (light in colour) assayed 4 ozs. 7 dwts., while darker conglomerate gave 5 ozs. 4 dwts. 11 grains, and conglomerate showing visible gold gave 15 ozs. 12 dwts. to the ton (Dr. George Tate). With only ten small and leaky heads the yield last April amounted to 244 ounces of gold, the ore milling nearly 13 dwts. to the ton. From 12 to 15 dwts. is said to be the average of the Main Reef Line of Witwatersrand.* The gold varies from the size of a pin's head to impalpable powder, and is waterworn. The conglomerate is composed of rounded

* See Official Handbook, Transvaal Republic, Mining and Metallurgical Exhibition, compiled by W. Y. Campbell, pp. 4 and 11. The averages for April, May, and June, 1890, were very constant, being 14¼ dwts., 14⅝ dwts., and 14½ dwts. of gold per ton respectively; latterly they have fallen off about 1 dwt. per ton.

quartz pebbles of various sizes, but seldom larger than a hen's egg, with occasional pebbles of hard quartzitic rock, set in a quartzose matrix often containing black titaniferous ore. It has not the reddish colour of the Witwatersrand banket found above the water-level, but resembles rather the greenish-grey pyritic conglomerate found below that level, although in the Gold Coast conglomerate no pyrites has as yet been met with. The gold occurs generally in the cement, and is sometimes seen collected round the quartz pebbles. Mr. Alford, speaking of the Witwatersrand banket, says:—"It is usually found that gold occurs much more freely in the matrix than in the pebbles of the conglomerates, and more so in that part of the matrix immediately adjacent to the quartz pebbles;" and Mr. Furlonge, referring to the De Kaap conglomerates, remarks that the gold is "entirely confined to the cementing material, which is to a large extent very porous."* On the other hand, a German writer distinctly says the gold is found both in the pebbles (Geschieben) and in the cement (Bindemittel);† and as gold has been found in a quartz pebble from a Carboniferous conglomerate,‡ and has been seen by Dr. C. Le Neve Foster in a pebble from a South African banket,§ it may be pretty safely concluded that gold also occasionally occurs in the pebbles of the West African bankets, although, commercially speaking, the quantity is probably of little or no account.

The workings at present are shallow, but they tend to show that the deposit becomes richer at a greater depth, which is also said to be a characteristic of some of the Witwatersrand bankets. A shaft is now being sunk to the dip in order to open up the seam below the present adit level. By continuing this shaft until a vertical depth of 250 feet is reached, and cross-cutting from near the bottom of it to the seam, the latter will then be opened up for a total depth of 500 feet on the dip, and for this district quite a respectable depth reached.

The writer thinks that the deposits will eventually be found to consist of sediments laid down in basins scooped out in schist; an outcrop of chloritic schist is seen a little south of Taquah.

A seam 2½ feet thick, with a roof of loose red clay or marl, has been proved north-east of the present workings on the slope of the hill, and about 100 feet above the old tunnel. This would appear to be a parallel seam, running about 130 yards south-east of the main seam. The best part consists of 15 inches of conglomerate, separated from the soft roof by 4 inches of pale sandstone containing layers of titaniferous iron. This seam will be cut by continuing the cross-cut of the old tunnel in a south-east direction. The native shaft, which is just large enough to allow one to descend hanging on to a rope, has struck the seam at a depth of 39 feet. The general strike is N. 31.° E. (true), and the dip from 50° to 55° N.W.

* See also Mr. Alford, *Mining Journal*, April 27th, 1889:—The conglomerates "are composed of imperfectly rounded waterworn pebbles of white and grey amorphous quartz in a matrix of ferruginous sand, all very solidly cemented together; small pieces of felsite, talc, mica, and other rocks are also occasional constituents of the mass. The gold appears to lie in the matrix, or rather to have agglomerated round the quartz pebbles on their gradual dissolution; sometimes on removing a quartz pebble from the conglomerate the cavity is seen to be completely lined with crystalline gold."

† *Neues Jahrbuch* (1889), vol. i. (Referate), p. 113.

‡ A. Liversidge, *The Minerals of New South Wales*, 1888, p. 24.

§ See discussion of Mr. Sawyer's paper, cited above.

Adjah Bippoh Mine.

About one mile north-east of Abosso there is a seam of conglomerate now being worked very similar to that of Abosso, but having a much greater dip; in fact in this respect it has the appearance of a lode. The bed strikes about N.E.; at the south end the dip is 60° N.W. (thickness 7 feet), along the centre it is practically vertical, while at the north end the dip is 75° S.E. (thickness 1 foot 9 inches). One portion of the seam is crossed by a joint running 10° S. of W. and dipping 75° N., which heaves it 10 feet to the west. The seam, 170 feet from surface was, in 1888, 3 feet thick, and gave an average of about 10 dwts. of gold to the ton. The cement of this banket is composed of blue quartz, and is much darker than that of Abosso.

Cinnamon Bippoh Mine.

This mine lies about two miles north-east of Adjah Bippoh, and the bed is found on the western slope of a steep hill which is a continuation of the Taquah and Abosso range. The seam is a most pronounced banket deposit, striking N.E. and dipping 45° N.W. The thickness varies from 2 to 3½ feet. The hanging-wall consists of sandstone rock containing thin streaks of titaniferous iron ore, poor in gold. Soft and light-coloured conglomerate occurs here very similar to that of Abosso, but the hard conglomerate is characterised by having a cement of blue quartz of even darker hue than that of Adjah Bippoh. The Cinnamon Bippoh Company's mine adjoins this, and the workings are in the same seam.

Crockerville Mine.

A little east of Abosso village two seams were worked some years ago—"Sam's Reef" to the north and "Crocker's Reef" to the south-west, but the writer is unable to give any particulars of their structure.

Abbontuyakoon Mine.

Three miles north-east of Taquah village, and on the road to Abosso, is a deposit, judging from specimens on the roadside, of the same nature as the Taquah main seam. The mine is now abandoned. A pile of old machinery on one side of the path, and the remains of a stone-breaker and a portion of the stamps-shed on the other, all overgrown with tropical vegetation, are sad relics of unsuccessful mining on the Gold Coast.

Effuenta Mine.

One mile south of the Taquah mine is a seam, striking with the hill or N. 6° E. (true) (Cameron), which appears to be strongly conglomeratic in places, for Mr. Thomas Cornish speaks of it as "6 to 8 feet of conglomerate and quartzite deposits, interspersed with boulders or blocks of quartz and ironstone." This mine is abandoned.

Teberibi Mine.

Two-thirds of the way from Bonsa to Taquah village is a deposit, not now being worked, very similar to the main Taquah reef, and which is conglomeratic in places (Cameron). At 100 feet from surface this seam yielded 6 dwts. of gold to the ton. The vein is said to dip 45°, and to be of a soft, friable nature.*

* *Reports on Gold Mines*, 1889 (Papers relating to H.M. Colonial Possessions, No. 66). Sir W. B. Griffith to Lord Knutsford, p. 9.

Geological Notes.

The district at present explored stretches for about 14 miles in a north-east direction, while the average width is small, being greatest at Abosso, where it measures about 3 miles. Commander Cameron speaks of gneiss being the country rock at Teberibi, Taquah, Effuenta, Adjah Bippoh, etc., and Mr. E. McCarthy also says the sandstones and conglomerates "are often so metamorphosed as to pass into gneiss." The writer has seen no true gneiss in the district, but sandstones, when veined with titaniferous iron ore, often assume an appearance closely resembling that rock.

The band of grit forming the roof of the Abosso banket appears to be of local character; the red marl, too, is not seen at all the mines; but it must be remembered that, with the exception of the latter, which contains a large proportion of clay, all these rocks are chemically the same, being composed in the main of rounded grains of quartz, and may be described as sandstones, conglomeratic sandstones, conglomerates or quartzites, according to the texture and the cohesion between the particles; at the one extreme is a rock which falls to pieces on the slightest touch, and at the other is a very hard quartzite, through which the natives were unable to pierce.

The beds have evidently been quietly deposited by water. Specimens from Taquah clearly show this, while even the pebbles of the conglomerates appear to be arranged roughly in layers—their longer axes being generally parallel to the roof and floor of the seam.* The gold, waterworn as a rule, is undoubtedly contemporaneous with the rocks in which it occurs, differing in this respect from the Witwatersrand and De Kaap banket reefs, the gold of which is said to be of more recent date than its matrix.† The main reasons for inferring this are (1) the crystallized nature of the gold, and (2) its presence in pyrites below the water-level.

The bankets of West Africa are alluvial deposits, but whether the sandstones and conglomerates have been deposited in the sea, or in an inland lake or lagoon, which latter seems probable, or on the bottom of a wide river, cannot yet be satisfactorily determined—a very careful geological examination of the whole district must be made to settle this question as well as that of the age of the deposits. If these deposits were built up on the bottom of a lagoon, the latter must have been of large extent with several rivers and streams emptying themselves into it. Near the mouths of such rivers we should expect to find the coarser materials deposited, while farther from the banks of the lagoon the fine matter would settle; and, again, the material deposited would differ from time to time according as the rivers were in a flooded or dry state. Along the shore at Axim and Winnebah the deposition of sand and titaniferous iron ore is seen going on at the present day: a little inland the native holes show titaniferous sand resting on a clay bottom—the fact of a thin band of clay occurring on the floor of the bankets at Abosso and Adjah Bippoh has

* A distinct bedded arrangement is also seen in a specimen of pyritic conglomerate from Witwatersrand, possessed by the writer.

† See J. S. Curtis (*op. cit.*); Mr. Furlonge (*op. cit.*), speaking of the De Kaap conglomerates says:—"The auriferous pyrites, and consequently the 'free gold,' is evidently of later date than the beds themselves."

already been pointed out. In the Appim district, near Winnebah (between Cape Coast Castle and Accra) outcrops of ironstone occur veined with quarts showing visible gold.* It is further said that the ironstone "is almost pure iron ore, and very hard to break, and does not occur in a continuous reef, but in detached boulders and small reefs dispersed through the quartz reef" It would appear from this that the boulders are the result of the wear and tear of some seams or veins of ironstone occurring farther in the interior. In considering the origin of the bankets it is also worthy of mention that M. Bonnat found that the bed of the Ancobra River, some distance above the first rapids, consisted of large flint pebbles (*gros cailloux roulés*), lying from 2 to 3 yards thick.

The banket deposits of Wassaw have clearly been built up from the disintegration of older rocks, and from the large preponderance in them of quartz, talc, and titaniferous iron, it is probable that the parent rocks consisted of talcose schists and quartzites, traversed by auriferous veins of quartz and ironstone; or the bankets may have been derived from conglomerates of older date than themselves, for if the former had been derived directly from schists and quartzites it would not be unreasonable to expect to find in them more angular and unworn fragments than is in reality the case—in other words, the bankets should show in many places a distinctly brecciated structure.

It is evident that the beds have, subsequent to their deposition and consolidation, been tilted up at an angle varying from 30° to 90°. As yet no eruptive rocks have been found in the district to account for this; "greenstone" it is true, crops out along the coast at Axim, and at Cape Coast Castle, and between these places, but it is of older date than the schistose rocks, which in their turn are older than the sandstone and conglomerates. There is also a marked absence of faults† in the district, the small heave in the Adjah Bippoh mine being perhaps the only exception known. The deposits are probably of comparatively recent geological age—the small cohesion observable in certain parts would appear to indicate this—and, with the exception of the band of hard quartzite rock forming the roof at Abosso, and of certain hard and compact portions of the coarse bankets, little or no metamorphic action can be traced—differing markedly in this respect from the banket reefs of South Africa.‡

There is evidently a series of parallel seams in the district; thus at Abosso four main seams have already been shown to exist. The workings not being continuous it is no easy matter to correlate the seams; but, judging from their relative positions, Teberibi, Abbontuyakoon, and Adjah Bippoh would appear to form one, while Effuenta and Taquah form another. The seams, as a rule, crop out on the western slopes of the hills, or towards the setting sun.

* *Reports on Gold Mines*, 1889, p. 21.

† "In places where the strata are observable in close proximity to the trappean rocks, the former are found dislocated, and traversed in all directions by surface fissures, in many cases very highly mineralised."—C. J. Alford *(op. cit.)*.

‡ "On its (*i.e.*, the Rand's) northern side there is a large mass of greenstone, dykes from which penetrate the hills, and almost always cause the metamorphosis of the sandstone into quartzite."—J. S. Curtis *(op. cit.)*. At De Kaap, "thrusting its way through all these formations, we find a vast irruption of trap-rock—mostly diorite—forming dykes with a general strike of N. and S. magnetic; also in a few cases intrusive sheets. Where the irruption has occurred amongst the stratified beds a considerable disturbance of these has naturally been produced, resulting in a dislocation of the rocks in its vicinity, and a metamorphism of their structure."—C. J. Alford, F.G.S., *Mining Journal*, 20th April, 1889.

Towards the north-east of the area the conglomerates become more and more clearly defined, while its south-western portion is characterised by alluvial deposits showing very little conglomeratic structure—the latter, too, are much more talcose than the former. This would appear to show that the current conveying the materials of the bankets came from the north-east.

It has recently been observed that the gold in some of the Witwatersrand bankets is not uniformly distributed, but occurs in large lenticular masses,* the dip of which is not stated; and the gold in one at least of the West African bankets occurs in shoots dipping south-west. At the Akankoo quartz fissure-vein mine the shoots of ore are said to dip in the same direction.

Mode of Working.

When the seam is very wide, the upper portion containing very little gold is left standing, but this necessitates careful propping. When the whole of the seam is taken out, props, stull-pieces or bearers, from 5 to 18 feet in length, are put up about 6 feet apart, the roof being of very strong nature. The timber used is wood of fair quality from the neighbouring bush. When the paying part of the seam runs only 2 feet wide, a portion of the roof is stripped down, and packed behind polings reaching from one stull-piece to another.

At Abosso the seam is partly being worked by underhand stoping, but when the engine shaft to the dip has cut the seam, the mine will be opened up in the ordinary way by overhand stoping; and the mineral will be raised to the new tunnel, now in course of driving, and trammed from thence to the mill.

For timber foundations karkum and kasaba woods are used; the former grows over 200 feet in height, and is then 11 feet in diameter for some distance from the base, it is very hard, and weighs 80 lbs. to the cubic foot. The latter is a fine timber very like oak.†

Amalgamation.

The process, as carried on at Abosso, is as follows:—Lumps of cyanide of potassium are occasionally put in the stamp-boxes; the pulp passes through fine sieves of No. 37 gauge on to upper amalgamated-copper plates 16 inches long, and inclined 5° from the horizontal; mercury is sprinkled over the upper parts of the plates from time to time, and cyanide is rubbed over them; or, better still, a mixed solution of cyanide and sal-ammoniac is used, and the plates are frequently brushed over from below upwards towards the head, in order to prevent the accumulation of the heavy ironsand on the plates. The pulp then passes over lower amalgamated-copper plates 8 feet 9 inches long by 22 inches wide, and thence over a narrow foot-plate on to the blanket tables, 8½ feet in length. The blanketing is washed every 2 hours in a large tub of water, and native women are constantly employed washing the blanket tailings in woolen bowls. The result is a large recovery of mercury and but little amalgam, showing that not much of the fine gold is caught on the

* *The Engineering and Mining Journal*, Nov. 1, 1890.
† *Further Correspondence respecting Affairs of the Gold Coast*, 1885.

blankets. The final tailings have been assayed and show less than 1 dwt. of gold per ton, so that it is believed that most of the flour gold is carried off on the surface of the water used for dressing purposes. The amalgamated plates used here are unusually long, the object being to catch as much of the fine gold as possible; as a matter of fact from 13 to 22 per cent. of the total amalgam is caught on the lower plates. The upper plates are cleaned three times a week, and by far the greater proportion of the amalgam collects on the first two inches of the plates; the lower plates are cleaned once a month only. The amalgam is very hard, and is scraped off with steel tools having a sharp edge; it is carefully washed on a separate amalgamated plate—all specks of ironsand are finally removed by a magnet—and then squeezed through chamois leather, made into balls and weighed. The amalgam is very rich in gold, 2½ ounces yielding about 1 ounce of the precious metal, of about 23 carats value, or between "standard" and "fine," and which realizes about £4 per ounce troy. The problem is to catch at least 80 per cent. of the fine gold. The fineness of some gold collected by Mr. Edward Dean from South African banket, may be gathered from the following facts:—The gold was in a brown dust; it discoloured white paper with a brown stain, and a small quantity gave a distinct purple colour to water with transmitted light, and light green with reflected light.*

Formerly Thénot's amalgamators were in use at Taquah; all the quartz when pulverized was forced through a large body of mercury confined in vessels, and this was kept in a state of constant agitation. The operation is said to have gone on without a hitch for several months, and the principle of it is almost perfect, theoretically speaking; but, as the amalgamators are now piled in a heap under an old shed, the process must in the long run have proved a failure. Mr. Jordan not long since patented a process for pneumatically forcing gold ore pulp through a column of mercury, but one has heard very little about it of late. Narrow and curved strips of amalgamated plates like those used in California† might be suspended across sluices, and, dipping just below the surface of the water, would catch some more of the fine gold; and a solution of bichloride of mercury is said to be very efficacious in saving fine gold.‡ The Macarthur-Forrest process§ would appear to be well adapted for the treatment of the tailings in these mines. This process depends on the affinity of gold for cyanogen; a solution of cyanide of potassium is used, a mere percolation of it through the mass being sufficient, it is said, for tailings derived from ores containing free gold. It is obvious that in this process a solution should be used not containing more than 1 or 2 per cent. of the cyanide, and if possible, the solution should be used over and over again, and not be allowed to escape and poison the surrounding ground. The details of the process are at present kept a great secret, but at least 80 per cent. of the gold is said to have been extracted by it from tailings obtained from the milling of South African bankets.‖

* *Notes on the Treatment of Gold Ores*, by Florence O'Driscoll, A.M.I.C.E., 1889, p. 40.
† Florence O'Driscoll *(op. cit.)*, p. 51.
‡ *The Engineering and Mining Journal*, Jan. 11, 1890.
§ *The Engineering and Mining Journal*, Dec. 21, 1889, and Florence O'Driscoll *(op. cit.)*.
‖ *The Engineering and Mining Journal*, Nov. 1, 1890.

Labour, Power, and Fuel Used.

Native Fantis, Kroomen, and Bassah men are employed to work the mines—the latter are the best miners, and the most easily managed. The Fantis are paid uniformly 1s. per day; with a good headman, who receives £2 to £3 per month, they work fairly well, but otherwise they become utterly unmanageable. Naturally of a most indolent disposition, and very fond of trade-gin, and the throwing of dice, they will cease work for the slightest cause, and often for no cause at all. They are great cowards, and a small stone falling from the upper workings will often be sufficient to make them all rush out of the mine pell mell, and refuse to work again for the rest of the day.

The imported Kroomen and Bassah men receive daily rations of rice (1½ lbs. per man) and beef once a week (1 lb. per man) in addition, and are paid from 18s. to 24s. per month, the headman of a gang receiving £2 10s., the second headman (only necessary in large gangs) £2 per month. A gang will consist of from 20 to 60 men. El Mina boys (in West African parlance = men) are used as hammock-bearers, and also for river transport work, and while native Fantis will only carry light weights—they require at the rate of about 6s. 6d. per long ton per mile along bush track—Kroomen must be employed for bringing up heavy machinery. The freight from the coast to the mines varies from £10 to £20 per ton—the river transport costing rather more than half this sum.

Each tribe must have its own village at the mine, otherwise there would be continual broils and fights. Free passages and subsistence are given to blacks brought from places up or down the coast. Each gang works for 12 months, and then returns home for a short time; a written agreement is made and read out to the assembled gang, each man of which is then called up "to touch the pen," and have a cross put against his name. By native custom this is equivalent to a signature or cross made by the man with his own hand, and is in every way binding. At some mines the blacks are paid a certain sum on account, from time to time, and receive, as well, cloth and other goods in lieu of cash, the balance being paid when their time is up. At other mines they have instituted regular monthly payments, keeping from one to two months in hand, and this is by far the better plan. Sufficient water can, except in some cases for a short time in the dry season, be obtained for dressing purposes, for feeding boilers, etc., while steam-power is used for driving machinery, wood being the fuel used. As the bush is cleared round the mines the cost of fuel will become greater and greater—light tramways will have to be put down to bring it in, and at some of the vein mines situated on the river the importation of coal is talked about. It is not improbable that coal may eventually be found to exist in the district, and a rumour of its discovery was rife a few months ago.

Leases.

The mines are leased from the king or head chief of the district, and are let for a term of from 50 to 100 years, at a dead rental of from £100 to £200 per annum —the king taking a certain proportion of this rent, and subsidiary chiefs the

remainder, usually in unequal proportions, according to their status, etc. In some cases a sum of from £100 to £200 is paid down on the granting of the lease, and subsequently a yearly rental of £100 is paid, as well as 3 per cent. of the net proceeds of the mines (Dahse). Great caution is required in dealing with the chiefs in these matters, as they sometimes grant concessions which have already been leased to others, or else which are found afterwards to largely overlap concessions with older titles, and a ruinous lawsuit may be the result.

The document of the lease should be clearly worded, the boundaries well defined, a map attached to the deed, showing the concession granted, and all adjacent ones correctly plotted in relation to the true north. The original document must be registered at Cape Coast Castle.

Machinery.

Belleville boilers and engines were formerly employed in the main, but they have recently given way to large horizontal and vertical multitubular boilers, and at one vein mine, situated on the river banks, Cornish boilers have been sent out whole, and floated up the river, properly encased in wood, to the mines. Horizontal and vertical engines and stamps made by Fraser & Chalmers, of Chicago, by Harvey & Company, of Hayle, Cornwall, by the Sandycroft and other well-known firms, have been erected of late years, and efficient winding and pumping engines by good makers are also rapidly coming into vogue, and superseding steam winches and sinking pumps. Mines situated some distance from the river are, of course, severely handicapped on account of the want of roads. The wisdom of waiting until the Government makes good roads through the bush may be questioned, and if the various companies had combined years ago in doing this work, they would now have most efficient plants erected, and be making large returns.

Cost of Working.

This, on account of the position of the banket mines, is high, but, by careful management, need not exceed 6 dwts. to the ton, and, with good roads and therewith more efficient machinery, could be reduced to 5 dwts., or in money value about 20s. per ton.

Production.

The writer is unable to give figures of the past production of these mines—the present production of the three most important ones is at the rate of about 5,000 ozs. of gold per annum, which will probably be doubled very shortly.

Climate.

The climate is undoubtedly bad, and, although the average temperature is not very high, the daily variation at certain seasons is considerable,* and the dense bush, with its numerous marshes and decaying vegetable matter, surrounding the mines, not to speak of their comparative nearness to the mangrove swamps of the coast,

* At Axim the daily average temperature is from 75° to 82° F., rising to 92° and 96° F., and falling at night to between 70° and 75°. At Wassaw the average temperature is about 77°. At Crockerville in 1880–1 the temperature ranged from 65° to 96°, the lowest variation in 24 hours being 7°, and the highest 26°. The highest rainfall in 24 hours was 3·30 inches.

undoubtedly combine to make the district an unhealthy one. The ordinary intermittent fever is rife, and no European is exempt from it for a long period. On the other hand, the unhealthiness of the Gold Coast is often grossly exaggerated, and illness and deaths have often been put down to the climate that should rather have been debited to the too frequent use of spirits and other excesses.

Europeans must take plenty of quinine, live temperately, and avoid exposure to the hot midday sun, as well as to the malarial mists of the early morning, evening, and night.* Farther up the Ancobra River, where the elevation exceeds 1,000 feet, the climate is said to be much less unhealthy.

The climate will gradually be improved as the bush is cleared, and the swampy land drained, but until the mines are placed on a good paying basis little improvement can be expected in this direction, unless the Government of the Gold Coast steps in and materially aids the mining companies.

History.

It is impossible to say if these mines were worked while the Portuguese were masters of the coast, but in the seventeenth century an anonymous writer† refers to the native method of working by digging deep pits, and washing the earth in great bowls. William Bosman in 1704,‡ speaking of the mines of Wassaw, may allude to the Taquah deposits, for he says the gold is found "in or betwixt particular hills," and that the negroes dig pits in order to obtain the precious metal, but it is certain that the mines were not then worked by the Dutch themselves, as they for some time only held the coast for trading purposes, and knew nothing of the interior except from native report. That they afterwards superintended the working of them would seem probable, as the remains of Dutch forts have been found in the neighbourhood of the gold mines of Essaman, but, on the other hand, John Barbot writing in 1732,§ says the mines were not then worked by the Dutch, and refers to forts having been erected to protect the trade with the natives.

In 1825 the prospectus of the "Gold Coast Mining and Trading Company" was issued‖ with a proposed capital of £750,000. Among other objects is that of "extending the intercourse now subsisting with the native chiefs and princes, and to make arrangements with them to introduce a better method of working the mines and pits in the Dinkara, Wassaw, Ahantah, and Fantie Territories on the Gold Coast and at Grand Bassam and Assim on the Windward Coast." This company, however, appears to have devoted its energies to trading only, and to have wisely left mining alone.

In 1874 the attention of M. J. Bonnat, while at home after his five years' captivity in Coomassie, was drawn to the gold of the Gold Coast, and the result was the formation of the *Société des Mines d'Or d'Afrique occidentale* for working mines in that

* Consult Dr. Nealon's letter, "Climate of the Gold Coast," *Mining Journal*, March 19, 1887.

† *The Golden Coast, or a Description of Guinney.* London: printed for S. Speed at the Rain-Bow in Fleet-street, 1665.

‡ *Nauwkeurige Beschryving van de Guinese Goud-Tand-en Slave-Kust*, etc., Utrecht, 1704, 4to; this work was translated into English *(A New and Accurate Description of the Coast of Guinea)* and French in 1705.

§ *Description of the Coast of North and South Guinea.* He says that above the falls and rocks the negroes dive for gold, and formerly the Dutch drove a very considerable trade there.

‖ There is a copy of this prospectus in the Reading Room of the British Museum.

country. This company appears to have been in the nature of a syndicate, its primary object being to secure river concessions and demonstrate the practicability of dredging the Ancobra River bottom for gold. Bonnat, with three companions, arrived on the coast on the 10th of April, 1877, and, after three years' exploration, he returned to France. In 1879 he was the means of forming the Franco-English *Compagnie Minière de la Côte d'Or d'Afrique*, or "The African Gold Coast Company." According to Bonnat's map of 1879, the concessions owned by this company were as follows:—Two river concessions, Mankooma (south of Essaman), Abosso, Taquah, and Tamso (*concession réservée*). The first mines worked were Abosso and Crockerville (Messrs. Swanzy & Co.) in 1879; Effuenta followed in 1880, Taquah in 1881, Adjah Bippoh (Wassaw Gold Mining Company), Abbontuyakoon (Gold Coast Company) and Teberibi in 1882. Poor Bonnat returned to the Gold Coast in 1881 to open up the Taquah Mines, and died there on the 8th July, 1882. "Le nom de Bonnat," said M. Verillon in 1883, "restera pour toujours attaché à la découverte des régions aurifères de Taquah et d'Abosso."* Meanwhile other travellers had visited this region—Mr. J. A. Skertchly, F.R.G.S.,† in 1877, and Herr Paul Dahse‡ from 1879 to 1881, followed by Burton and Cameron in 1882. Mr. Skertchly admirably describes the native mode of working the mines, and at the time of his visit there were upwards of 6,000 men and women at Taquah working gold.

Previous to 1886, Taquah and Abosso were worked separately, and then by *la Société Fermière des Mines d'Or de Taquah et d'Abosso*. In 1888 the mines were taken over by an English company, which is at present engaged in vigorously opening them up.

ADDENDUM.

In one specimen of banket from Abosso the writer has detected a crystal (cube) of gold, and it is also seen sometimes in thin plates. The fact of its occasional occurrence in a crystallized form in this deposit may be accounted for on the very probable supposition that some of the gold has only recently crystallized out from solution. A bedded deposit in such a position is subject to the same surface changes as those that occur in a true fissure-vein, and a great portion of the gold, if not dissolved, would, at any rate, be re-arranged in the deposit, and in this way its occurrence in "shoots" may be accounted for.

Reference has been made to M. Bonnat's examination of the Ancobra River bottom—the point chosen was Aodowo, 20 miles above Tumento; he employed native divers for this purpose, and he found that the upper stratum consisted of a "very compact" mixture of comparatively small pebbles, broken quartz, and white sand, forming 20, 30, and 50 per cent. of the whole mass, and below this large pebbles buried in auriferous whitish clay ground. General Wray, who was with M. Bonnat, and has himself examined the bottom of the river in a diving dress, describes it as being composed of from 5 to 8 feet of white quartz pebbles lying upon 1½ feet of pipe-clay, below which is an unknown thickness of auriferous sand. It is interest-

* *Voyages, aventures, et captivité de J. Bonnat chez les Achantis*, par Jules Gros, 1884.
† *Op. cit.*
‡ *Op. cit.* A translation of Dahse's paper, by Mr. R. B. N. Walker, was published in 1882, but cannot now be obtained.

ing to find that a conglomerate deposit is now being formed along the bottom of the Ancobra River, and the result of a current flowing over such a bed and bearing gold, ironsand, etc., in suspension is worth considering. There would be a great drag along such a bottom, and the heavy gold and ironsand would have a tendency to drop on to and filter through the mass; the quartz pebbles would, in fact, act to a certain extent like the stones forming the "pavement" of an hydraulic sluice, although the effect would be less on account of the axes of the pebbles being horizontal and not vertical as in sluices. In this way the great richness of the lower part of the Abosso banket can be partly accounted for, as well as the smaller proportion of gold in those deposits that contain few pebbles (*e.g.*, Taquah).

In a MS. sketch map, compiled by General Wray, the land immediately to the east of the Ancobra River, between Akankoo and Tumento, is said to be composed of "beds of conglomerate resting in slate," while the country to the west is described as "trap overlaid with clay;" the former beds most probably form part of the ancient bed of the Ancobra River.

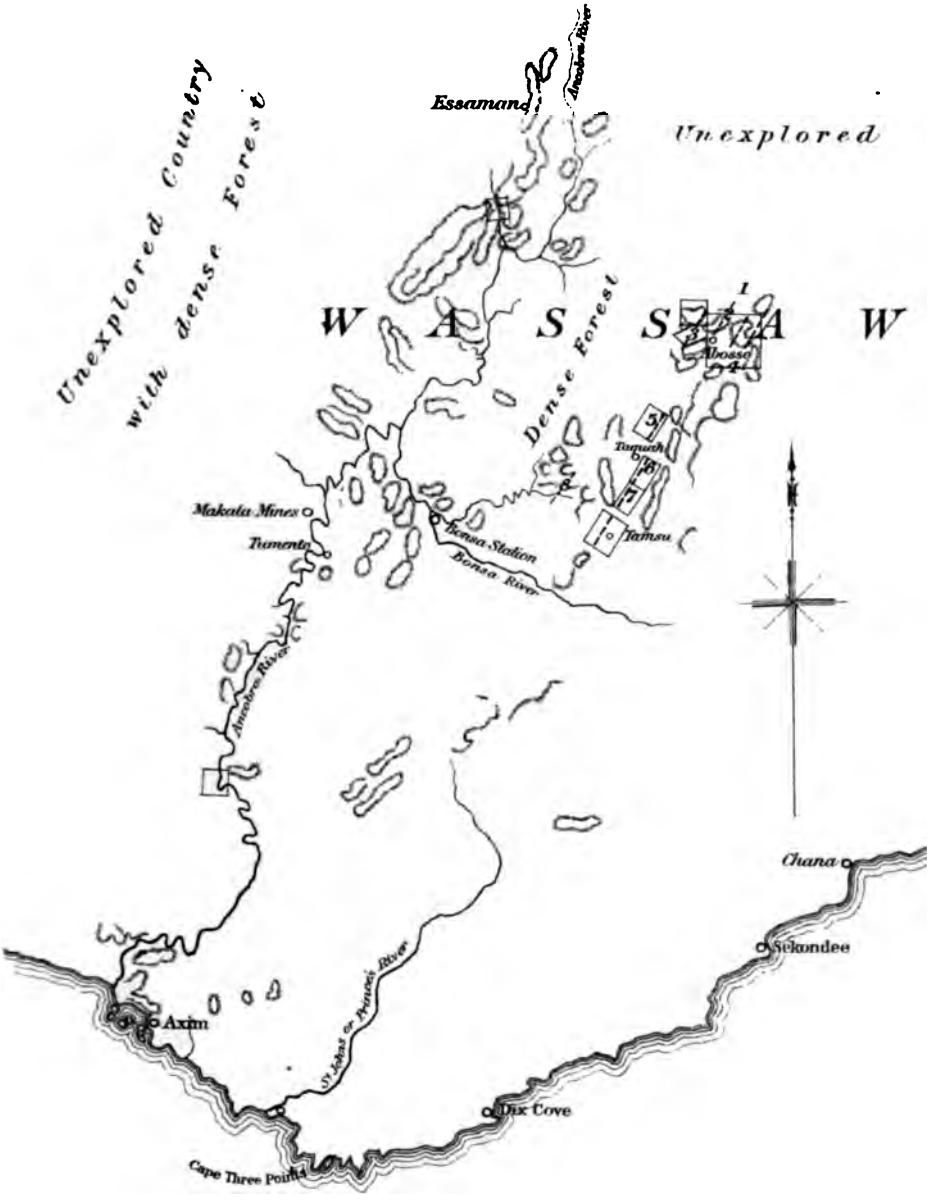
The blue colour of the quartz forming the cementing material of certain of the bankets has been pointed out. Similar quartz, showing visible gold, occurs in the fissure-veins of the Akankoo mines much lower down the river, and Mr. F. W. Rudler, F.G.S., has drawn the writer's attention to the fact that blue quartz is characteristic of some of the gold reefs of India. Formerly quartz of this colour was thought to be non-auriferous.

Where visible gold occurs in the cement of the bankets, a greenish discolouration (? talc) is sometimes seen. The yellow quartz of the true fissure-vein of the Essaman mine, higher up the river, is often similarly discoloured where it shows visible gold, and the writer has seen the white quartz of the Ibague district of Tolima, Colombia, South America, stained green and blue (? copper) where there is visible gold.

In the *Engineering and Mining Journal*, of Nov. 22nd last, the treatment adopted in the McArthur-Forrest process is stated by Mr. W. de L. Benedick to be as follows:—"The ore is first pulverized to a fineness of 40 to 60 mesh, and it is then mixed with a dilute solution of cyanide of potassium and thereby agitated. Six hours' treatment in the vats is generally sufficient to dissolve the gold and silver. The mixture is then transferred to wooden tanks, where it is allowed to settle, and the supernatant liquor is drawn off and passed through zinc shavings, which cause the precipitation of the gold and silver." The process, the patent rights of which have been secured in this country by the "Cassel Gold Extracting Company," has, as yet, scarcely gone beyond an experimental stage.

Mr. M. WALTON-BROWN read the following paper by himself and Mr. W. Foggin on "Experiments with Carbonite":—

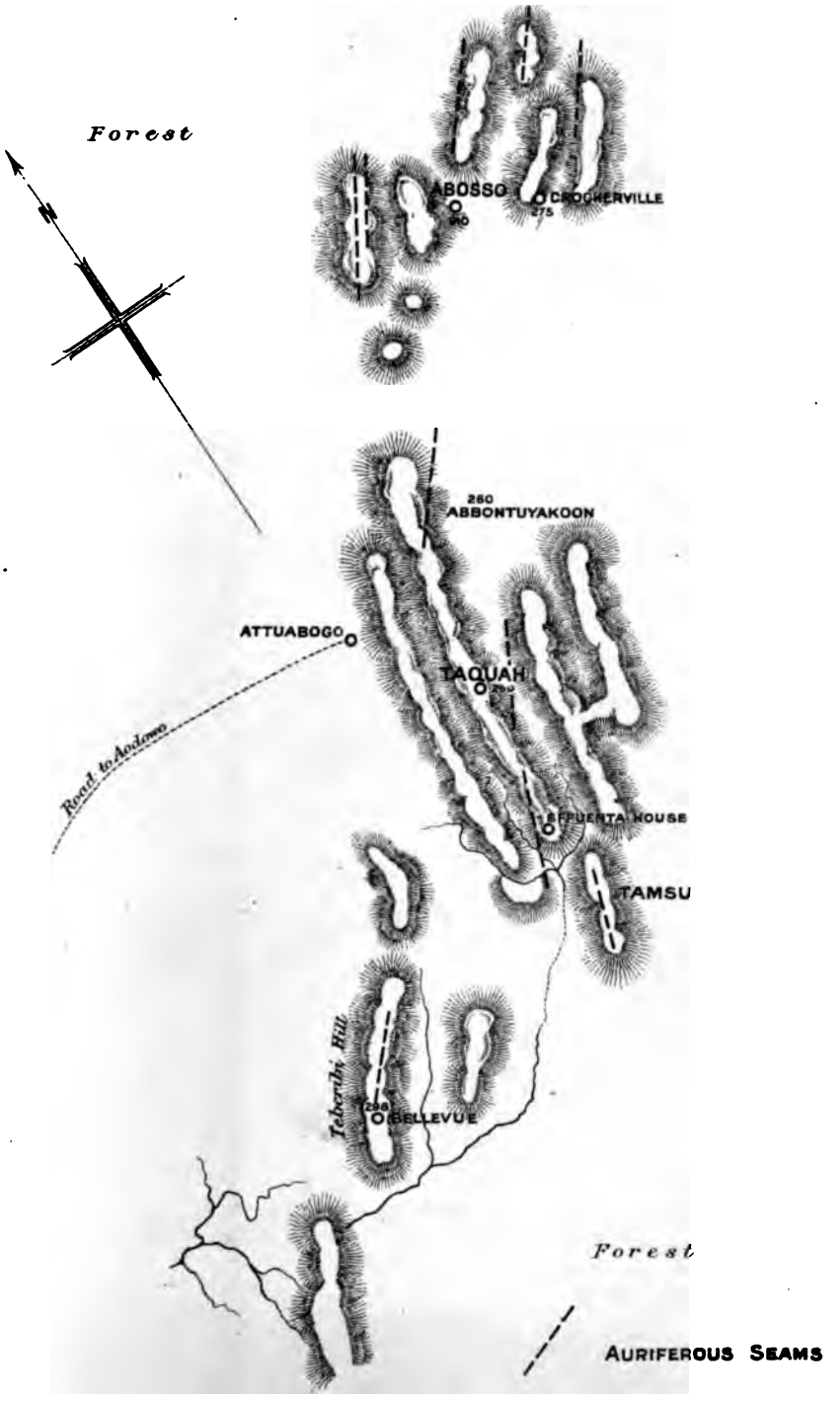
To illustrate Mr. Edward Halse's paper on "Some Banket Deposits of the Gold Coast, West Africa."



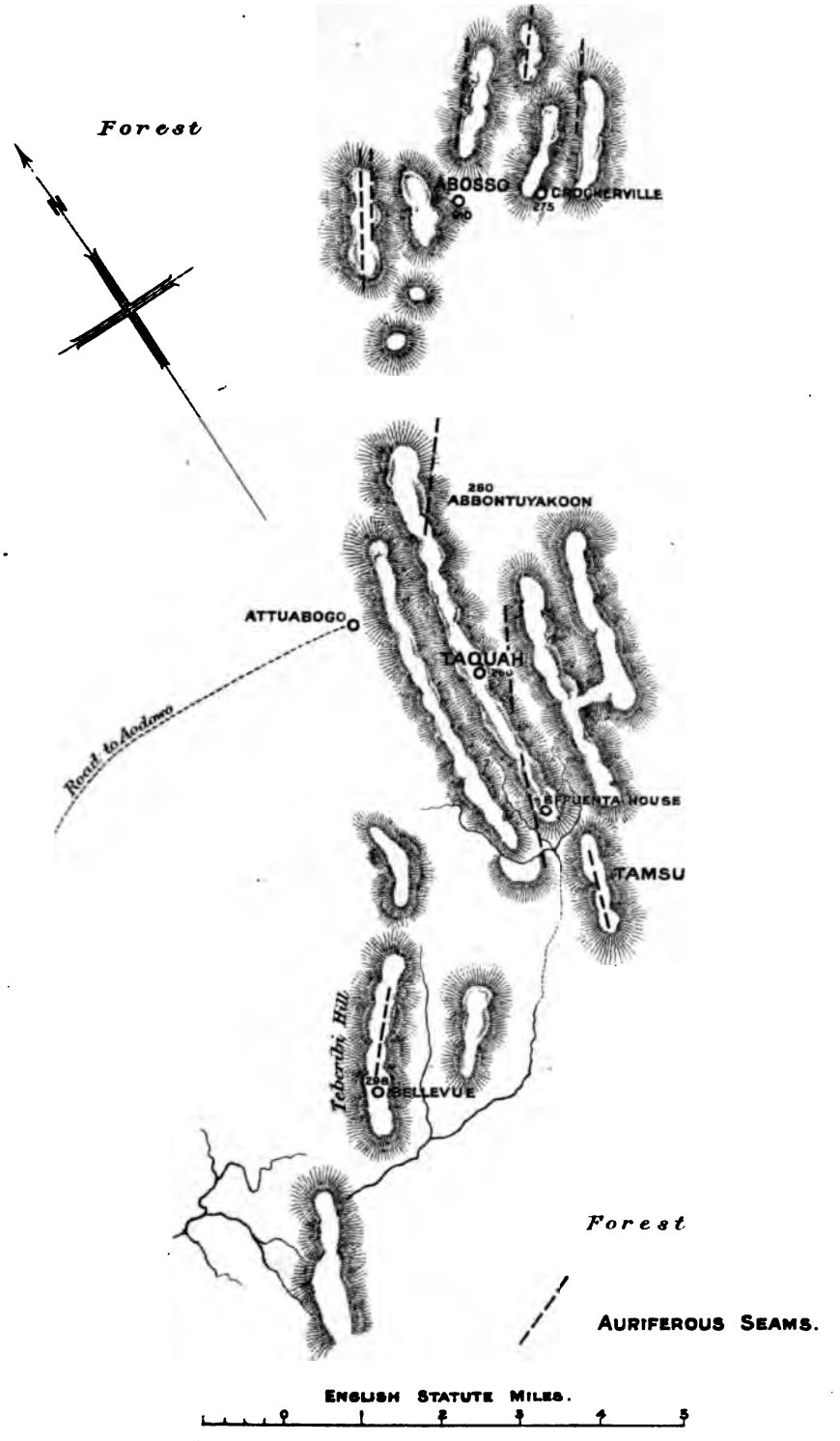
1 Cinnamon Bippoh Mine.
2 Adjah Bippoh Mine.
3 Abosso Mine.
4 Crockerville Mine.
5 Abbontu yakoon Mine.
6 Taquah Mine.
7 Effuenta Mine.
8 Teberibi Mine.
/ Auriferous Seams.

10 5 0 10 20 30 STATUTE MILES.

To illustrate Mr. Edward Halse's paper on "Some Banket Deposits of the Gold Coast, West Africa."

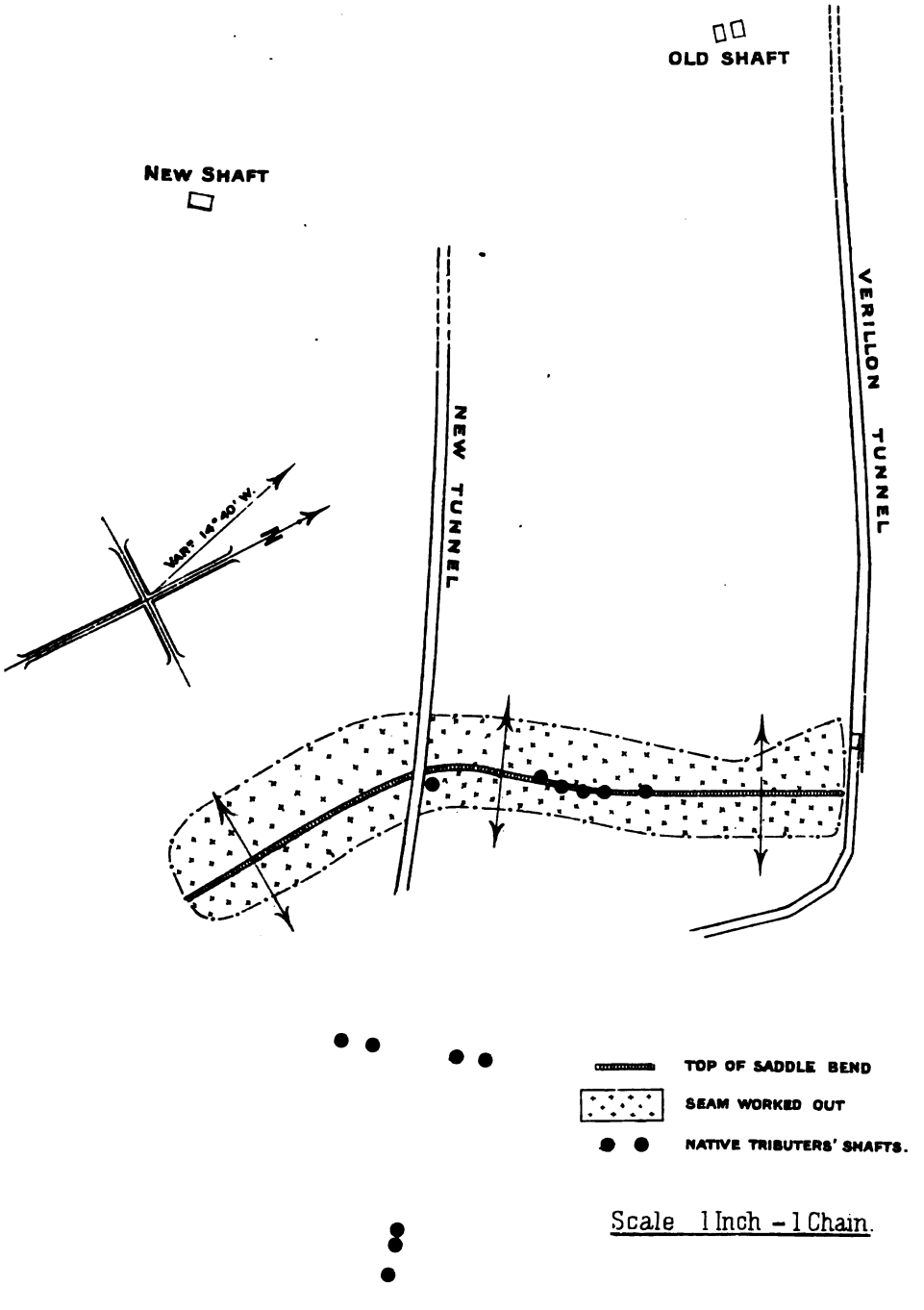


To illustrate Mr. Edward Halse's paper on "Some Banket Deposits of the Gold Coast, West Africa."



To illustrate Mr. Edward Halse's paper on "Some Banket Deposits of the Gold Coast, West Africa."

PLAN OF TAQUAH MINE.

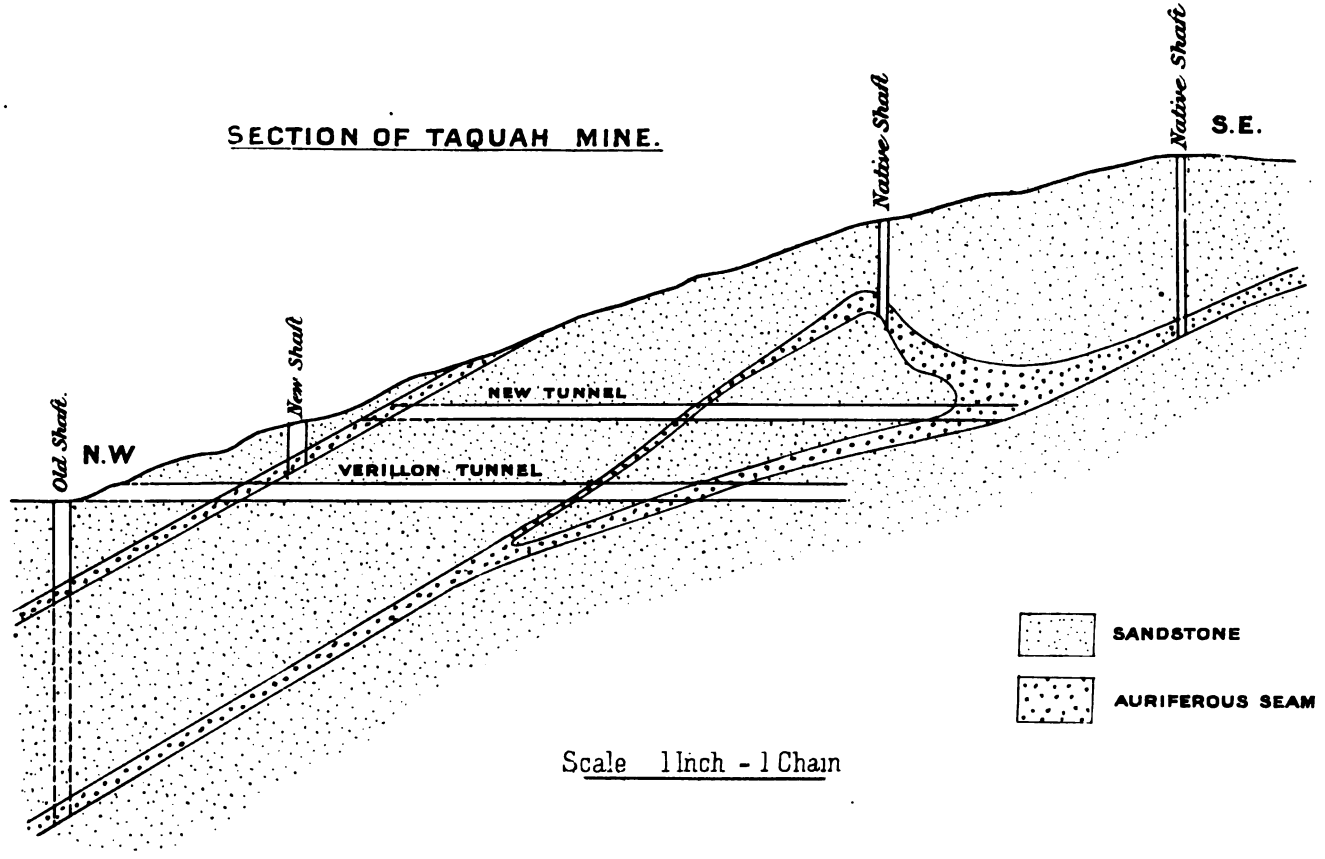


Scale 1 Inch – 1 Chain.

And.ᵂ Reid, Sons & Cᵒ Lithos Newcastle.

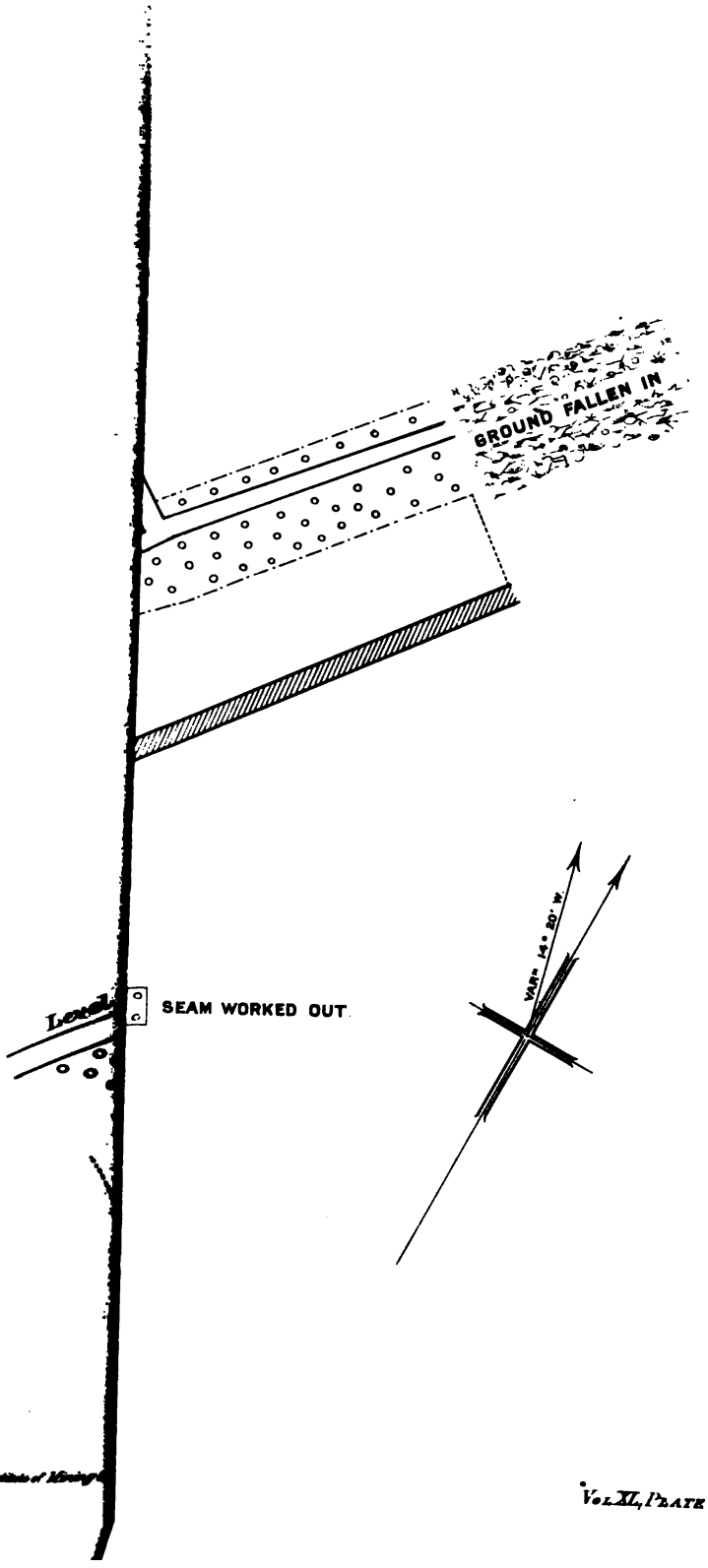
Federated Institution of Mining Engineers
Transactions, 1897-98

To illustrate Mr. Edward Hulse's paper on "Some Banket Deposits of the Gold Coast, West Africa."

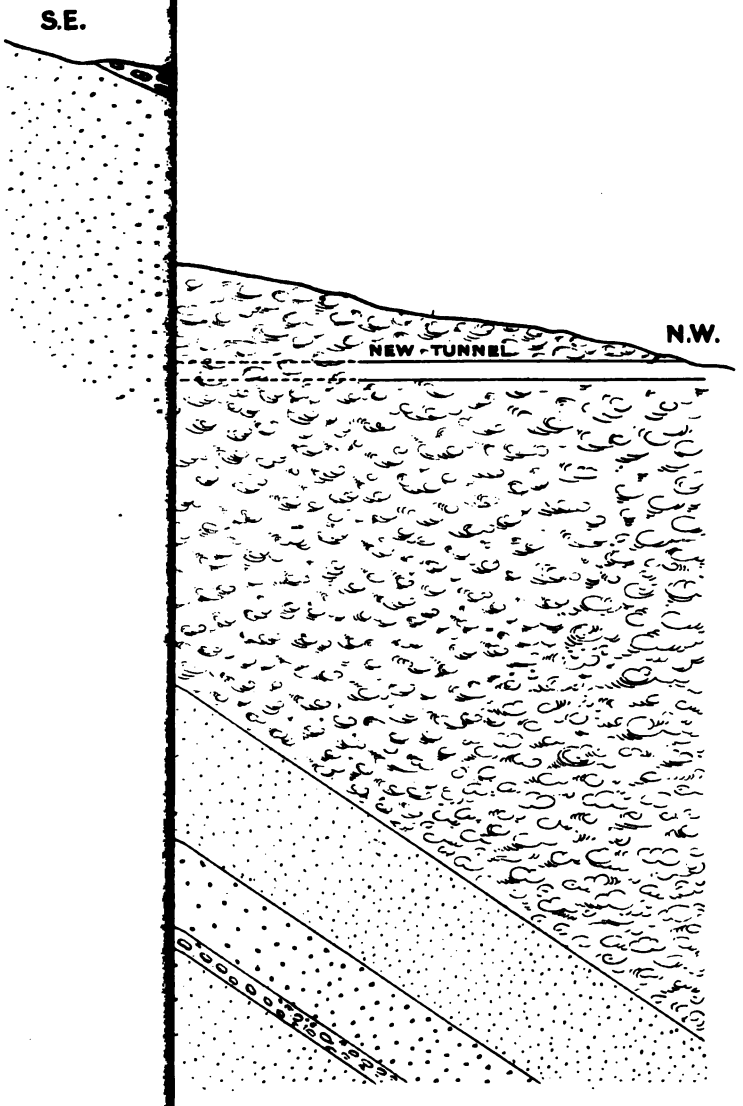


Transactions 1890-91.

C, West Africa.



West Africa.



EXPERIMENTS WITH CARBONITE.

By M. Walton Brown and William Foggin.

As the experiments with carbonite at Cymmer Collieries showed that when fired in a cannon and unstemmed it might ignite explosive mixtures of natural gas with coal-dust, the following further experiments were made at the North Biddick Collieries in order to determine this question more exactly.

I.—Description of the Apparatus. (Plate XIII.)

The apparatus used consisted of a gas chamber and a cannon.

The gas chamber, *a* (with a capacity of 126 cubic feet), was made from a boiler tube 17 feet 10 inches long, and 3 feet in internal diameter, and one of whose ends, *b*, was covered with a flat plate, with an opening 10 inches in diameter. This chamber was simply laid upon the soil.

The cannon, *c*, was made of forged iron, 11 inches in diameter and 4 feet 7 inches long, fitted with holes 1¼ inches diameter, at one end 18 inches long, and at the other end 14 inches long. This cannon was firmly secured to a small tram, *d*, by which it could be withdrawn from the partially closed end of the boiler, re-charged, returned into position, and fired into the boiler, whose axis and that of the cannon were coincident.

The gas chamber was fitted with two openings, *e* and *f*, on the top, each 8 inches diameter, and with a sight hole, *g*, 10 inches by 8 inches, which was covered with a strong iron framed glass window.

The gas chamber was closed at the open end, *h*, with a sheet of brown paper, firmly secured to the end of the boiler by an india-rubber ring. The other and partially closed end was covered by the cannon, and made more perfectly tight by an india-rubber wheeze.

A fan blade, *i*, was fitted in the middle of the length of the gas chamber, and could be rapidly vibrated by means of an external lever and a long cord, *k*.

Ordinary lighting gas was supplied from Messrs. Newall & Sons' gas works, near Washington station, and was measured into the chamber through a 50-light meter, and discharged into the boiler about 12 inches from the firing end.

Each charge was fired with one No. 6 Nobel detonator, by means of one of their electro-magnetic exploders.

II.—Carrying out of the Experiments.

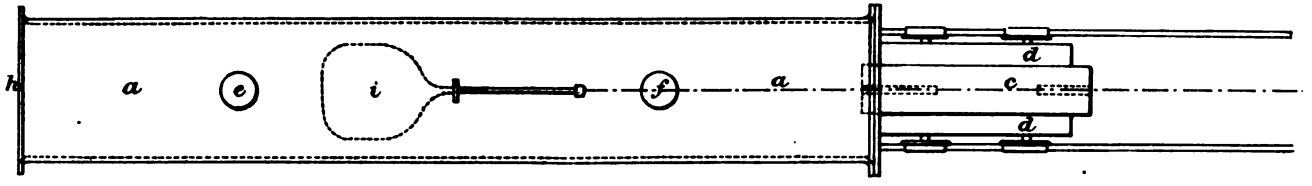
The experiments were made under the same conditions as were in force at Cymmer Colliery as far as practicable. The shots were fired without stemming into the explosive mixtures, containing from 10 to 15 per cent. of gas mixed with air.

Date.	Number of Experiment.	Weight of Carbonite used.	Number of Cartridges used.	Nature of Cartridge Case (if any).	Quantity of Gas used.	Percentage of Gas in Mixture.	Coal-dust used.	Position of Detonator from Outer End of Hole.	Results.
		Ounces.			Cub. Ft.		Lbs.		
1890.—Oct. 21st (at night)	1	8	4	None.	13	10·3	6	Covered with 2 ounces of carbonite.	Ignition, long flames issued from openings in boiler, with vivid red sparks.
	2	6	3	None.	13	10·3	6	Do.	Do.
	3	8	4	None.	13	10·3	6	Do.	Do.
	4	4	2	None.	13	10·3	6	Do.	Do.
	5	2	1	None.	13	*10·3	6	Covered with 1¼ ounces of carbonite.	No ignition, flame of shot seen distinctly.
	6	2	1	None.	13	*10·3	6	Do.	Do.
	7	2	1	None.	13	*10·3	6	Do.	Ignition, long flames from openings in boiler with vivid red sparks.
	8	2	1	Paper.	13	*10·3	6	At outer end of cartridge.	No ignition, flame of shot seen distinctly.
	9	2	1	Paper.	13	*10·3	6	Do.	Do.
	10	2	1	Paper.	13	*10·3	6	Do.	Do.
Nov. 5th (at night)	11	6	3	None.	18	14·3	6	Covered with 1 ounce of carbonite.	Ignition, long flames issued from openings in boiler with vivid red sparks.
	12	4	2	None.	18	14·3	6	Do.	Do.
	13	8	4	None.	18	14·3	6	Do.	Do.
	14	4	2	Paper.	18	14·3	6	At outer end of outer cartridge.	Do.
Nov. 24th (daytime)	15	2	1	Paper.	18	14·3	None.	At outer end of cartridge.	Ignition, long flames issued from openings in boiler and dense clouds of brown smoke.
	16	2	1	Paper.	6	4·7	None.	At inner end of cartridge.	Do.

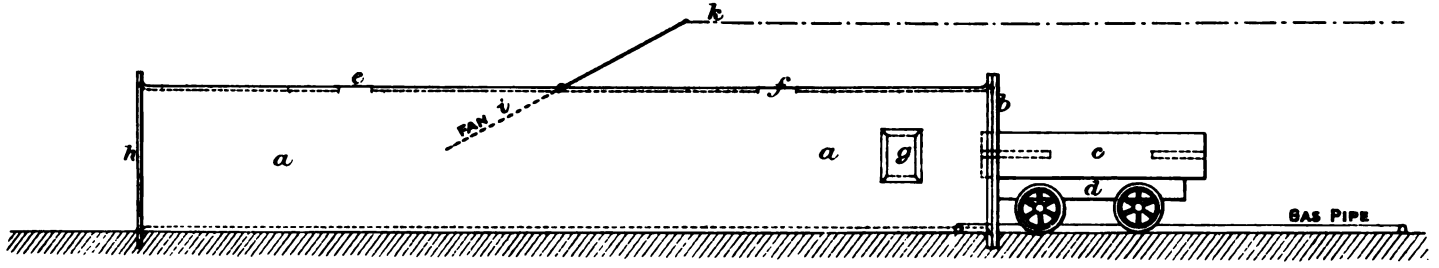
* The wind increased in violence during these experiments, and the previous shots having shattered the glass window, caused a leakage of gas, which was detected at a distance of 36 feet from the boiler, and it is possible that the mixtures had become non-explosive by dilution with air.

Federated Institution of Mining Engineers
Transactions 1890-91

To illustrate Mess^rs. M. Walton Brown & W. Foggin's paper on "Experiments with Carbonite."



GROUND PLAN.



LONGITUDINAL SECTION.

Scale 4 Feet - 1 Inch.

The experiments were conducted as follows:—

The cannon being withdrawn, the charge, with detonator attached, was inserted and pressed to the inner end of the hole with a wooden rammer. The firing cable was then attached, and the cannon run forward into the boiler ready for firing. The various openings in the gas chamber were closed, and the gas passed into it, during which time the fanner was vigorously worked to and fro in order to mix the gases.

In some of the experiments fine coal-dust was thrown into the chamber at the two upper holes before the gas was introduced.

These experiments accord with the opinion of one of the writers, as expressed at the discussion at the last meeting; they are at variance with the results of the experiments in Germany and at Cymmer, but confirm the opinion of the French Commission, viz.:—That the explosives which can be best recommended, as regards safety, are dual mixtures, such as octo-nitric cotton, mononitronaphthalene, dinitro benzol, and naphthalene with nitrate of ammonia or other bodies.

In the case of mixtures of dynamite with nitrate of ammonia or other bodies, the unconfined detonation appears to be irregular as regards the phenomena of the ignition of the explosive mixture. It seems probable that these irregularities may be due to the difficulty of obtaining perfection of mixture of the substances.

At this point Mr. J. B. SIMPSON took the chair in place of Mr. G. B. Forster, who was compelled to leave.

Dr. BEDSON said he would like to ask what was the composition of the carbonite used? He understood there were various kinds.

Mr. J. A. G. ROSS said if they had any explosive engendering high pressures, it was naturally accompanied with flame, and the heat produced an explosion if there were explosive mixtures near the position of the explosive, inasmuch as the production of mechanical energy naturally produces an immense amount of heat. In every explosion the adjoining atmosphere, contiguous to the explosion, was brought to a very high temperature. As an illustration of this he might mention the common experiment with a small syringe, about ¼ inch diameter, when the piston is rapidly pressed down by the hand, sufficient heat is produced to ignite the tinder. In the same way it was probable that the increased temperature of the atmosphere, caused by the detonation of an explosive, would be sufficient to ignite an explosive mixture.

Mr. A. L. STEAVENSON said the results of these experiments seemed to prove what he said at the last meeting, that no explosive was absolutely safe; and it only remained for them to ascertain which was relatively the best. He approved of carbonite and of gelignite used with the water cartridge. Some valuable experiments had been made by Mr. H. Hall, H.M. Inspector of Mines, which were

recently reported in the *Colliery Guardian*. Disused shafts were used in which the explosives could do no harm, and the shots were fired at the bottom of the shaft by electricity from the surface. A little coal-dust was thrown down the shaft, and on the ignition of the explosive the flame came out at the top of the shaft. He could not conceive a more valuable means of testing. In each experiment he believed that the coal-dust when ignited, without any gas being present, sent out a flame just as if the pit had fired. Nobody who saw this could take the slightest exception to the fact that coal-dust was explosive. He had no doubt that the explosion at Tudhoe was from coal-dust. There were plenty of disused shafts in this district; let them try the method! No one would take any harm, and it could be seen at once whether or not the dust was ignited and blown out.

Mr. THOS. BELL asked if Mr. Hall had sent a copy of the report mentioned to Prof. Lebour?

Mr. M. WALTON BROWN said that he had received two copies, and had placed a copy in the library of the Institute.

Mr. C. R. BARRETT asked if Mr. Brown thought that the carbonite shots, if stemmed, would have given the same results? He (Mr. Barrett) tried a few experiments a few weeks ago on an engine plane where they could go back in a straight line about 300 yards and watch the effect from both ends. In no case did they see any flame or sparks. The shots were all placed in the topstone and were properly stemmed; he tried some in the face of a stone drift, but in this instance the carbonite did not work so efficiently.

Mr. HENRY WHITE said he had used a very large quantity of carbonite during the last six months, (generally above 100 shots a night) and considered it worked remarkably well. On the first occasion, they tried some very difficult shots, amongst others, in a stone drift, in a very hard post, almost whin, and being able to remain within 12 to 25 yards of all the shots, they had good opportunities of observing whether there was any flame or sparks, but neither were seen, after most careful watching by several persons. They were still continuing its use, and found it to act most efficiently. Not a single instance of either spark or flame had been reported by any of the shot-firers, who were instructed to watch most carefully. He might also add that he had received an excellent account of it from the viewer of one of the largest and most fiery collieries in South Wales, where it had been used for about a year.

Mr. W. ARMSTRONG, Jun., said he had used roburite for two years, and unless when there had been imperfect stemming, they had never seen the slightest spark or appearance of flame.

Mr. W. FOGGIN said that the object of the experiments described was not to test the safety of carbonite or its effect in use; but simply to confirm or disprove the results of certain experiments described at the previous meeting of the Institute by Mr. M. Walton Brown. If the fact had been established that they had an explosive which was perfectly flameless without tamping, they could be satisfied as regards safety. The present experiments proved that, so far as absolute flamelessness was concerned, carbonite was no better than any of the other explosives. He had tried most of the

so-called flameless explosives, and they all produced flame and lighted explosive mixtures when the hole was unstemmed. With stemming, it was a different matter; it was possible to fire a gunpowder shot (if properly stemmed) without any flame; and before the last paper on this subject was read he had conducted some experiments with a view to finding out which of the high explosives was safest with a minimum amount of stemming. These experiments were not yet finished, but some of the explosives tested showed remarkable degrees of safety. Two or three were perfectly safe with 2 inches of stemming; others were not safe with 9 inches. He was not prepared to name at the present moment those which were almost absolutely safe and those which were dangerous. It would be invidious to do so in view of the numerous explosives in the market, as it was more a question for the Flameless Explosive Committee, who were about to commence their experiments.

Mr. D. BURNS said he would like to ask Dr. Bedson if he was in a position to state at what degree of compression of the atmosphere explosive mixtures might be ignited, and if sufficient force could be generated by the explosion, as suggested by Mr. Ross, to reach that degree of compression and developed heat? If Mr. Ross's contention was true—and there seemed to be a great deal of force in it—it did not become a matter of the flash or flame but of the explosion itself. There was certainly an explosive wave produced, and if that wave generated sufficient heat, it could ignite inflammable mixtures when it passes through them. Perhaps the reason of the experiments, in the shaft previously referred to, being so successful in causing a flame to come to the top of the shaft, was due to the fact that the air was not free to expand in all directions so as to allow the force to be dissipated, and being confined in the shaft, it was able to ignite the dust floating in the shaft. He had never thought before of inflammable gases being fired by compression produced by the explosive wave; and it seemed to be like fighting the air to try and get an explosive which would not ignite gas, unless, indeed, they could get such a slow explosive that an explosive wave would not be produced.

Mr. J. A. G. ROSS said he was sorry that he had not the tables of heat produced by compression at hand, but they could easily be obtained. In modern artillery pressures of 14 to 20 tons per square inch were found, and in the old cannons it attained 30 tons per square inch. He presumed the pressure engendered at the mouth of the shot hole would be from 12 to 20 tons per square inch, and the temperature engendered from that would be tremendous. The advantage he saw in not producing flame was that the flameless explosive would produce an explosion merely at the aperture, whereas the others carried the burning points or solid incandescent particles to a greater distance.

Dr. BEDSON said the question was one which it would be beyond his province to explain. The enormous temperatures referred to as produced by explosives were, of course, on the assumption that the explosion took place in a closed vessel: such conditions would not apply to ordinary shot-firing either with or without stemming, as in consequence of the instantaneous expansion of the gases their temperature is greatly reduced.

Mr. M. WALTON BROWN said he had read the official record of the experiments referred to, and there seemed to have been no apprehension of gas being found in the shafts used for the trials. It was quite possible that there might have been gas present. In one instance the experiments were made in an upcast shaft, attached to a pumping shaft half a mile distant, and as the air appeared to reverse while the dust was being thrown down the shaft through a hand-riddle, it was possible, if any gas was given off in the mine, that the air might become sufficiently charged with gas so as to form an explosive mixture at the instant when the charges were fired. Mr. Steavenson seemed to think the experiments showed the explosive nature of the coal-dust in the shaft, but he believed that the flame only reached the top of the shaft in three out of six trials at the White Moss Shaft; that is, the flame extended a distance of about 60 yards from the shot, whereas in a colliery explosion the effects were felt, more or less, at very great distances.

Mr. THOS. BELL—Did it not blow the head gear down in one case?

Mr. M. WALTON BROWN said he did not think that the head gear had been damaged in any instance. It only appeared in three cases at the surface in the White Moss experiments with charges of 1 lb. of powder; in two cases the dust was not ignited, and in the other the dust was ignited, but the flame did not reach the top of the shaft. The second series of trials, made by Mr. H. Hall at the Southport Pit of the Haydock Collieries, were made in a sinking shaft 130 yards deep, connected with an adjacent sinking shaft by a short drift in a coal seam at a depth of 100 yards, where the cannon was placed upon a scaffold. Six experiments were made in this shaft, with charges of from 1 lb. to 1½ lbs. of powder, and in every instance the coal-dust was not ignited. A third series of experiments were made at the Big Lady Pit of the Haydock Collieries. This pit is 210 yards deep, in which a scaffold, placed at a depth of 180 yards, supported *two* cannons. The downcast (a pumping) shaft was 21 yards distant, and connected thereto by two small drifts at depths of 180 yards and 210 yards respectively. The air in this case is reported to have been quite free from gas. Three sets of experiments were made at this shaft. In the first set, out of five pairs of shots in which from 2 lbs. to 3 lbs. of powder were fired, in three cases the coal-dust was ignited, and in two cases the flames appeared on the surface. There were six pairs of shots in the second set of experiments, in each of which 3 lbs. of powder were used; there were two cases in which the ignited dust did not appear at the surface; in the third case the flames reached the surface. In the last set of seven experiments, in which from 3 lbs. to 4 lbs. of powder were used, the dust was ignited in two instances; in the first the flame did not reach the surface, but in the second, in which 6 cwts. of coal-dust were used, and the last of the series, the flame and smoke issued from the shaft for five or six seconds. Mr. Hall's results could be summarised by stating that the coal-dust was ignited by heavy charges of blasting powder in twelve out of thirty experiments, and that the flame only appeared at the surface in six trials. In three cases the flame traversed a vertical height of 180 yards in a shaft of 8 feet diameter, and in three cases in a shaft of 7 feet diameter it attained a height of 60 yards. These

experiments appear to confirm the conclusions of Messrs. Mallard and Le Chatelier—(1) that the combustion of coal-dust is not an explosion, and such combustion only produces in the case of most dusts unimportant mechanical effects, which are always inferior to those of gas explosions, even in the case of the most inflammable dusts; (2) that the combustion does not extend over the whole area covered with dust; (3) that the length of dust ignited in a mine is proportional to the intensity of the mechanical action which has raised and ignited the dusts; and (4) that this length is always limited, and in the case of blown-out shots of ½ lb. of powder this limit does not exceed 65 feet for most dusts, and only reaches 200 feet in the case of very exceptional dusts. It will be recognised that in three of Mr. Hall's experiments, when 1 lb. of powder was fired the flames attained a vertical height of about (50 + 10 =) 60 yards; and when 1½ lbs., 2½ lbs., and 3 lbs. of powder were ignited the flames attained a vertical height of (180 + 13 =) 193 yards. It will be recognised if the flame of ½ lb. of powder and coal-dust was transmitted to a horizontal distance of about 200 feet, that it would not be inconsistent with Messrs. Mallard and Le Chatelier's conclusions, if the flame of 2½ lbs. to 3 lbs. of powder with coal-dust was experienced at a vertical height of 200 yards, in the case of a very exceptional dust. If the effects of ½ lb. of powder are felt at a distance of 200 feet, by proportion, the effects of 2½ lbs. might be reasonably expected to become apparent at a horizontal distance of even 1,000 feet. Mr. Barrett asked the effect of stemming upon carbonite. This question had not been tested in their joint experiments, which were specially made to test a statement of the manufacturers that carbonite was safe without stemming. He might, however, mention, in a general way, that exhaustive experiments made in Germany and France showed that the length of stemming had great effect in reducing the apparent temperature of the explosive and the possibility of the ignition of gas. One speaker suggested an explosive that could not produce flame; none of those invented up to the present time appeared to have reached that point. It was the fact that the ignition of a gaseous mixture required the existence of a certain temperature, and numerous experiments were being made to produce an explosive substance whose temperature of detonation would not reach that temperature.

The CHAIRMAN said that after this instructive discussion he would propose a vote of thanks to Mr. M. Walton Brown and Mr. W. Foggin for bringing so interesting a subject before them. He was afraid they had not yet reached the flameless explosive period, but trusted that the experiments which were being made would induce inventors to come forward, and that in time some explosive would be found which would be flameless. So far as he could see, if the water cartridge could be introduced it would be an effective way of "scotching the snake," but he did not know that the experiments with it had been very conclusive.

Mr. THOS. BELL (H.M. Inspector of Mines) said he had much pleasure in seconding the vote of thanks. He hoped the discussion would be adjourned, as there would be a good deal more to say about it.

On being put to the meeting the vote of thanks was cordially adopted.

ELECTRIC MINING SAFETY-LAMP.

The SECRETARY exhibited two electric mining safety-lamps, supplied by the Mining and General Electric Lamp Company, at the request of Mr. G. B. Forster, and read a report thereon by Professor Frankland. The smaller lamp weighed about 3 lbs., and would burn for upwards of 14½ hours; the larger lamp weighed 4 lbs., and was made to run 7 hours. The light given by the two lamps was respectively one and two candles.

The CHAIRMAN—It seems to be the best we have seen. What is the price?

Professor LEBOUR said the price was about 25s.

Mr. H. AYTON said he had tried one of these lamps, and instead of giving two candles, as it was supposed to do, it scarcely gave one.

Professor LEBOUR said it had been explained that the lamp Mr. Ayton tried had not above half the capacity of even the smaller lamp now exhibited.

Mr. STEAVENSON said one of the dangers of an electric mining lamp was that the man using it might be suffocated before he was aware of the presence of gas.

CHESTERFIELD AND MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

GENERAL MEETING,

HELD IN THE TOWN HALL, DERBY, JANUARY 10TH, 1891.

MR. JOHN JACKSON, PRESIDENT, IN THE CHAIR.

The PRESIDENT reminded the meeting that the Council had arranged for the General Meeting to be held in different centres, and in the ordinary course Derby had been selected for to-day. Judging from the number present, he rather feared the bareness of the agenda paper might in some degree be the cause, and he was sorry to admit that it was the blankest that had been submitted at any time in his recollection. Without papers the interest in the Institution must considerably fall off, and it naturally depended on the members whether that was to be so or not. Amongst their body were a considerable number of intelligent and clever men, who, if they would take the trouble and give the time, could furnish interesting papers on mining matters. He sincerely hoped that they were not likely to fall off in that direction, and that the number and merits of the papers in the future would be as gratifying as they had been in the past, and that those who were in a position to do so would help with contributions and supply material for discussion.

DISCUSSION ON MR. CHARLES SOAR'S PAPER ON "COAL-LOWERING ARRANGEMENTS AT GRANVILLE COLLIERY (SOAR'S PATENT)."

The PRESIDENT said some comments upon this method of delivering coal into wagons were made at a previous meeting, and as Mr. Soar was now present any further questions upon the paper would no doubt be answered by him.

Mr. C. J. OLIVER (Grassmoor Colliery)—What sized coal is the largest Mr. Soar's apparatus will deal with?

Mr. SOAR—Say 24 inches long and 12 by 12; that is about the largest.

Mr. H. LEWIS said he considered Mr. Soar's arrangement a very admirable one for dealing with tender coal, as it delivered the coal into the truck bottom without any fall. In the case of hard coal, which would stand tumbling about, it was another matter; but for soft coal it was a very good arrangement indeed.

Mr. J. BAGNOLD SMITH (Newstead Colliery) was of the same opinion. He said that some years ago he had to investigate a complaint from a customer in London—a

householder—who said that the coal received was three-quarters slack. He found that the coal had to be shot down a hole 16 feet above the cellar level; and that no doubt accounted for the complaint. Whatever precautions they took at the collieries, unless the householders adopted some ordinary precautions against undue breakages there would always be complaints.

Mr. SOAR—My contrivance was designed to meet the requirements of our colliery, and it has answered its purpose very well. It is not my business to deal with the matter Mr. Smith has mentioned. The coal is lowered into the trucks without any breakage. If it is roughly handled afterwards, that has nothing to do with the apparatus.

Mr. H. LEWIS asked the quantity the apparatus could deal with?

Mr. SOAR said that depended on the *dimension of the belt;* it would deal with *all* the belt would take.

Mr. H. LEWIS—What quantity have you yourself dealt with?

Mr. SOAR—Say 400 tons in about eight or eight and a half hours. There would be no difficulty in dealing with considerably more. Although our belts may be considered rather narrow (the cobbles belt is 2 feet 6 inches wide, and the nuts belt 2 feet wide) they are quite large enough for our purpose.

The PRESIDENT said that the contrivance was very ingenious and would assist any colliery which had to deal with tender coal. There could be no doubt that coal which could be retailed with the least amount of slack would find the readiest sale. As regarded Mr. Smith's remarks, no doubt they were very good, but at the same time that aspect of the question was a domestic matter which he did not think it was the business of colliery engineers to deal with, or which they need trouble themselves about very much. It was to their advantage to load coal as large as practicable; for as he had said, the larger the coal the more marketable it was. The paper had produced a considerable amount of interest, and he begged to propose a vote of thanks to Mr. Soar.

The proposition was carried amidst applause, and Mr. SOAR briefly replied.

DISCUSSION ON MR. ALBION T. SNELL'S PAPER ON "THE DISTRIBUTION OF ELECTRICAL ENERGY OVER EXTENDED AREAS IN MINES."

Mr. J. A. LONGDEN (Teversal) said, that with the consent of the President, he would like to ask a question which he had asked before, but to which he had not yet received any answer. He could not understand how in America a current of 1,000 volts was sufficient to kill a man, whilst Mr. Wallis, of Derby, had withstood a shock of 1,200 volts without suffering any injury. As he said before, Mr. Wallis had not offered any explanation of that fact; and it did seem somewhat incomprehensible that one man should be declared dead after receiving 1,000 volts, whilst a larger current did not materially affect another man. As regarded the

application of electricity to mining purposes, one of the things people fear is that there may be fires or other accidents through its use; and one of his under managers had that day, in a conversation with him on the subject, desired information, as an electric plant was in process of erection in one of the pits under his charge. He should like to learn more accurately as to the risks which may be incurred by using electricity underground.

Mr. HENRY DAVIS (Derby)—As far as I can gather from Mr. Longden's remarks, he is anxious to ascertain what is considered a dangerous pressure on electrical mains. It has been reported that Mr. Edison has been asked what he considers a dangerous pressure, and that he will not give any decided answer to the question. There is no doubt that a current which might prove fatal to one man might not affect another, so much depends upon the constitution of the recipient of the shock, and also the conditions. Men have received a shock of 2,000 volts pressure and not suffered any permanent injury; but in some cases we hear of it has proved fatal. With proper, even ordinary precautions, there need be little fear, and he did not think that the low voltage of electrical currents employed in mining could be considered dangerous. Mr. Snell in his paper went fully into the question of electrical engineering in mining, and in effect stated that at that time there was no safe method of constructing electric motors for use in the working face of a fiery mine, the danger in this case being the possibility of gas igniting from the sparks thrown off at the brushes. This source of danger had so far practically stopped a very large and important application of electrical engineering, and up to a few weeks ago no practical method of overcoming the difficulty had been suggested. A system of rendering harmless the sparking at the brushes of electric dynamos and motors had now been designed, but as he (the speaker) was interested personally in this invention, he should like to ascertain if it was the wish of the President that he should refer to this subject at the present meeting?

The PRESIDENT—Certainly. This is a matter of the greatest possible interest.

Mr. DAVIS—This invention is one in which Mr. Stokes is my co-patentee; and although I have not Mr. Stokes's permission to go into this matter here, it is a subject of such importance to mining engineers that I feel I am justified in introducing it. Mr. Davis then described the nature of the invention, but stated that as the system would probably be the subject for a paper to be shortly read before the members of this Institution he would not go into details.

Mr. G. E. SMITH (Nottingham) said that formerly when birds were found dead near telegraph wires they were said to have been killed by electricity; but as birds could not get one leg on to the wire and the other on the earth they did not complete the circuit, and consequently they did not die, as was popularly believed, from electric shock, but from the shock of blows received in flying against the wires. A man in America was said to have been set on fire by electricity and burned to death; but it transpired that he was carrying a can containing some highly inflammable oil that caught fire, and to that cause the death was attributable. He thought they ought not to give credence to all the ills which were attributed to electricity.

Mr. LONGDEN said, that although there was something in what had just been said, electricity was not a thing to be played with. In the event of a fall of roof it was obvious there might be a serious accident if the positive and negative wires were to break and the ends to meet on the floor. Mr. Davis had mentioned that only low pressure was used underground, but that was not so, for at one of his (the speaker's) collieries they were working at a pressure of 460 volts; and if any accident occurred, say in the night, especially in what the Home Office termed a "dusty mine," and where the dust was really inflammable, the consequences might be unpleasant. He repeated that he did not think electrical engineering underground was quite the simple thing that some people seemed to imagine.

Mr. H. LEWIS—Bury the cables.

Mr. J. B. SMITH—Or take the positive down one road and the negative down the other. They could not come into contact then.

Mr. H. DAVIS said if they were going to use 500 volts they would have to be careful. It was a rather high pressure to take into a mine. The cables would have to be well insulated and kept well apart, and the terminals of the motor would have to be well protected. But with a system laid out properly there was not the slightest danger, and any fire which might arise from the cables would be a disgrace to the electrical engineer. Referring to the rules of the Phœnix and other leading fire offices on the subject, he thought it would be well to follow the basis of their rules in colliery installations, and added that, although in the United States fires were frequent, there had not been one fire in the United Kingdom where the Phœnix Fire Office rules had been followed.

Mr. H. LEWIS did not see how the Davis-Stokes invention could be effectually tested except underground, and in gas. He would not like to be in the pit when the test took place.

Mr. LONGDEN explained the arrangements of his own electrical plant, and said that a recent invention, in which carbons were used for brushes, had reduced the sparking to a minimum. It was answering admirably, and he thought the idea would be of considerable use in carrying out the Davis-Stokes patent.

Mr. DAVIS said that the mere boxing up of the dynamo or motor was not an effectual safeguard. He had seen the invention Mr. Longden had referred to, and whatever brushes were used, sparking at the commutator was at times inevitable. But in damp places carbon brushes were stated to be unsatisfactory. It was very possible, as Mr. Longden said, that the carbon brushes, with the improved safety commutator that had been mentioned, might be of very great service indeed. His (Mr. Davis's) firm would shortly put down a motor fitted with the improved commutator at the Blackwell Company's Shirland Colliery, in Derbyshire, where the pump to be driven was a mile from the dynamo. Within the next three or four weeks he hoped the apparatus would be working, and then no doubt the members who so desired could inspect it.

DISCUSSION ON MR. E. B. CLARKE'S PAPER ON "THE STAUSS SYSTEM OF COLLIERY CAGE PROPS."

Mr. J. A. LONGDEN remarked that the author of the paper on the Stauss props was present, and said it did not appear that there was any economy except where they decked.

Mr. E. B. CLARKE (Sheffield) said that he was promised a model of the prop and gearing to bring before the next meeting and it would fully explain itself.

The PRESIDENT—It is not in use here, is it?

Mr. LONGDEN—At the colliery managed by Mr. Garforth?

Mr. CLARKE—No. It is not in use yet in this country. Abroad it was chiefly worked where balance platforms were used at pit bottoms for loading the cages, as at Messrs. Pope & Pearson's Colliery, Normanton. The economy in time would be greatest where three or four deck cages had to unload to one level. This system appeared to have increased the drawing capacity of the pits fully 13 per cent. in the Belgian collieries, as promised at the outset. A complete set of the Stauss cage props are about to be supplied for use at two shafts of the Earl of Dudley's Coneygre Colliery.

The PRESIDENT said it was an interesting matter, and he was sure the members would be pleased to inspect the working.

DISCUSSION ON TECHNICAL EDUCATION.

Mr. T. A. SOUTHERN (H.M. Inspector of Mines) said that, with the permission of the President, he would like briefly to draw attention to the subject of technical education for miners. There was an opportunity at present for the County Councils to devote a considerable amount of money to the promotion of technical education; and miners were strongly entitled to consideration. The origin of the matter was that three-quarters of a million of money had been voted by Parliament for this purpose. In Nottinghamshire certain proposals were being considered and had been referred to a special committee of the County Council. The leading idea of these proposals was that they should fix on several mining centres in the county, and provide interesting lectures for the miners at a merely nominal charge for admission. The lectures should be of a simple and elementary character, amply illustrated by diagrams, lantern slides, models and experiments, and would undoubtedly prove of great benefit to all ranks of those connected with the mining industry. The miners would not, as was often the case with lectures, be scared away with the idea that they were expected to know a great deal before they came. He mentioned the subject that day because it was at present before the County Councils. It was a matter of the greatest interest to that Institution, and no doubt there were many members of the Institution who had influence with members of the County Councils, and who would doubtless be glad to do their utmost to see that the interests of mining industry were not overlooked or inadequately provided for. It was felt that something should be done to improve the technical education of miners, and there was

little doubt that such instruction would tend to reduce the number of accidents, many of which were the direct result of unskilfulness or ignorance of even the first mechanical principles, particularly in regard to the setting of timber.

Mr. LONGDEN said the President was not present at Nottingham when the Board of Examiners for granting certificates of competency had discussed this question. He suggested that they might that day pass a resolution asking the County Councils to allot a portion of the amount at their disposal to the mining interest. In the President they had a member of the County Council of Derbyshire, and in Mr. H. Lewis they had a member of the County Council of Nottinghamshire.

Mr. H. LEWIS said the subject was one of great interest to himself, and had not escaped the attention of the County Council of which he was a member. Of course they had many claims, and agriculture seemed to be in great need of help, but it was certainly intended that mining should be remembered. He had personally advocated upon the committee the importance of providing for the training of the mining community and the necessity for making the lectures attractive and suitable for working colliers. In his opinion the classes held in the past had not commended themselves to the miners, as it could not be expected that men would go six or seven miles after a hard day's work to attend a lecture. Therefore they must take the lectures to the men. He had impressed upon the committee the claims of miners, and had pointed out that more technical knowledge amongst colliers must ultimately have the effect of diminishing accidents.

Mr. G. E. COKE called attention to the experience of the mining course lately held at the University College, Nottingham. Distance appeared to be no serious obstacle to attendance, provided the hours and train service were convenient. Some attended the lectures from as far as Pyebridge, but not a single working collier from Nottingham joined the class, though several thousand must be living in the borough. A series of popular lectures on mining subjects showed a similar result.

Mr. SOUTHERN said that the classes under the direction of the Science and Art Department were not adapted for coal miners, for, owing to the nature of the examination and the system of payment by results, the instruction given related more to metalliferous mining, and was altogether unsuitable to coal miners. In Derbyshire there were only two mining classes under the Science and Art Department, and not one in either Notts, Leicestershire, or Warwickshire.

Mr. J. B. SMITH said his connection with the Chesterfield science and art classes was for a period of over eight years, and their experience was similar to that of Mr. Coke. They had students from Staveley, Whittington, Barrow Hill, and Clay Cross, but very few indeed from Chesterfield. It was difficult also to teach men (many of whom did not possess a knowledge of the commonest principles of arithmetic) the most elementary principles of mechanics, chemistry, etc.; and if they came to touch on a common subject, say specific gravity, the men could not follow the simplest example. He had been conducting a night school at Newstead, and many of the lads and young men who were said to have passed the fifth standard could not do second standard work within three years of leaving school. It was necessary,

if they must take them forward to higher work, to get a good foundation, and without such a foundation it was impossible to gain anything like satisfactory results.

The PRESIDENT said they might be assured that he would not lose sight of the matter they had been discussing. The mining interest should have his hearty support, and he would do what he could to push it forward in this County of Derbyshire. He quite understood the difficulties Mr. Smith had mentioned as having occurred in his (Mr. Smith's) own experience, and it appeared to the speaker that it would be best to get hold of the boys directly they had left school and before they had time to forget what they had learned. If they could get them at thirteen years of age, the work would be much more easy and satisfactory than having to re-educate the lads in what they had once learnt and forgotten. I thought we were going to have a blank day, but it has proved a very enjoyable and profitable meeting. I have pleasure in proposing that the best thanks of this meeting be accorded to the Mayor of Derby for his kindness in allowing us the use of this room. I am sure we all feel our indebtedness to his worship.

Mr. H. LEWIS seconded the proposition, and observed that they all felt the great privilege they were granted of meeting there occasionally.

Mr. G. E. COKE proposed a vote of thanks to the Chairman, which was carried with acclamation.

Mr. JACKSON briefly acknowledged the compliment.

The following paper on "Germans," by Mr. F. S. Marsh, of Birch Coppice Colliery, Tamworth, was taken as read in the absence of the author :—

GERMANS.

By F. S. Marsh.

In the Midland District, during the past seven years there have been 6 fatal and 116 non-fatal accidents caused by the use of explosives underground.

Many of these have been caused by the use of germans defectively constructed, or by inefficient means taken to light them.

The chief causes of failure of the german have been :—

1st—In the fireman not allowing sufficient time to return to a place of safety.

2nd—In lighting the german instead of the match or touch-paper.

3rd—In returning to the shot before it has exploded.

During the past seven years 25 accidents have occurred, two being fatal, which can be placed under the 1st head; 15 accidents, two of which were fatal, under the 2nd head; 5 accidents under the 3rd head. It was to minimize such risks as the above that a new german was introduced in January, 1889, at the Birch Coppice Colliery. This german is a tin tube 3 inches in length, and of such a bore that a safety fuse can be readily inserted for one-half of the length of the tube, which is securely fastened by pincers to the fuse. The remaining half of the tube is then filled with common sporting powder, and the end sealed up with soap or tallow, which completes the german ready for use. This german is used in the ordinary way, viz. :—The hole is bored for the main charge, which is then, on the point of a greased copper spindle or needle, pushed to the back of the hole, damp holing dirt is then rammed home, the spindle withdrawn and the german placed in the spindle hole, leaving out one inch only of fuse, which after being secured in place by clay is ready for firing. By the use of this german the time allowed for it to do its work is controlled by the management, who by specifying a sufficient and uniform length of fuse ensure for the fireman time enough to retire to a place of safety, and at the same time relieve the fireman of the responsibility of an error of judgment on his part in timing his german by match or touch-paper, as he was obliged to do with the old forms of germans.

At Birch Coppice Colliery, for shots in the coal face, 9 inches of fuse has in practice been found an ample length to remedy the first cause of failure. It is obvious that this german effectually removes the second cause of failure, as the fuse can only be lighted at the end.

Returning to the shot before it has exploded has been the cause of serious accidents, which have many times happened, because, although the german had

fired or gone off, pieces of paper had been left smouldering at the back of the hole next the charge of powder. This gradually burnt until the main charge was reached, resulting in explosion, whilst the fireman had reasonable cause to suppose that the charge had missed altogether. A case occurred where the german fired and bounded out of the spindle hole: while the fireman thinking a piece of dirt had blocked the hole again put up the spindle to clear it, and in doing so pushed a piece of smouldering paper on to the charge, which exploding, fatally injured him.

The writer would submit that this class of accident cannot occur with the tin tube german, because, 1st, directly the german is fired the charge of powder in the tin tube is sufficient to throw the german, with considerable violence, out of the spindle hole, this invariably happens; 2nd, there is nothing of a combustible nature in the german which can be left smouldering in the hole.

Men have returned to a shot before it had exploded, because they thought the match or touch-paper had gone out clearly showing that in the old way of making germans great errors of judgment could and did occur. With a uniform length of fuse in the tin tube german, a time fuse is made which the men quickly get accustomed to, and which has been found very reliable. Besides which, the report subsequent to the explosion of powder in the tin tube is sufficiently loud to give good notice that the german has fired, but not loud enough to denote that the main charge has exploded.

During the twenty-two months the new german has been in use at the Birch Coppice Colliery, upwards of 66,000 have been used without any failure or mishap in any shape or form. When shots are fired at gate lips, back lips, or in headings, longer fuse is used, regulated by the management, according to the distance from the shot to a place of safety.

Bickford & Smith's No. 7 fuse has been found the most reliable of any yet tried by the writer, the running being very regular, a whole ring burning out in from 10 to 12 minutes, averaging 55 seconds per foot. A gross of these germans with 9 inches of fuse cost, for fuse, 1s. 5d.; tubes, 1s. 2d.; powder, 8d.; or 3s. 3d. in all.

For those who would use electric exploders, but are deterred through the risk of exploding the detonator whilst tamping, the writer may mention that he has tried some successful experiments to overcome this.

The main charge being prepared in the usual way as if a german were going to be used, a small detonator is put in a tin tube about 2 inches in length, which is then filled up with powder and the end sealed. The cables are connected to the detonator, which can then be pushed as far down the spindle hole as is considered desirable, the cable should then be secured at the entrance to the spindle hole by two wooden wedges and clay. Nothing then remains to be done except connecting the cable to the exploder, when the shot may at any time be fired. In this way the detonator meets with no violence.

Many other kinds of german have been tried by the writer, who found the most treacherous of all in one manufactured by pyrotechnists, consisting of a four-fold thickness of brown paper rolled in tube form, with touch-paper at the lighting

end, which, on being lighted, burns down to a fuse preparation about 1¼ inches in length and timed for 30 seconds; this in turn ignites the powder which fills the remainder of the tube.

From experience gained during the use of many thousands of these germans or squibs, the writer found they varied in quality so much that whilst some parcels would not have more than 1 or 2 per cent. miss or hang fire, other parcels would have so much as 14 per cent. either miss or hang fire. On one occasion the fireman whilst using one of these squibs at a gate end lip waited half an hour before he went to see why the shot had failed; he then drew the german out of the spindle hole, but it was so hot that he dropped it on the floor. It at once exploded. After this occurrence a 10 yard length of wire was tied to the german before lighting (one end being up the benk along the coal face), so that if the german failed to go off in a few minutes the fireman withdrew it by the wire. This answered fairly well, but there remained the risk of leaving smouldering paper in the spindle hole.

All the old forms of germans, whether the lighting end be dipped in brimstone, greased with tallow, or made with touch-paper and lighted direct, are little worse than matched germans and straws, which have become much more unsafe since high ventilating currents have come into vogue, as it is now impossible to time them with any degree of certainty, and except in very low velocities of air current they should never be used.

MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD AT THE ROYAL VICTORIA HOTEL, SHEFFIELD, FEB. 17TH, 1891.

MR. JOSEPH MITCHELL, PRESIDENT, IN THE CHAIR.

The minutes of the last meeting were read and confirmed.

The following gentlemen were elected Members of the Institute, having been previously nominated:—

Mr. Joseph Prestwick, Safety-Lamp Manufacturer, Eccles, Manchester.

Mr. W. Parkin, Colliery Manager, Rylands Main Colliery, Barnsley.

Mr. James Ed. Shaw, Colliery Owner, Darlington Hall, Pontefract.

Mr. Walter George Trench, Chemical and Mechanical Engineer, Faversham, Kent.

Mr. Isaac Ford, Colliery Manager, Rotherham Main Colliery, Rotherham.

THE FEDERATED INSTITUTION OF MINING ENGINEERS.

The minutes of the Council meeting of the Federated Institution of Mining Engineers, held at Newcastle-upon-Tyne, on January 21st, 1891, were read.

The PRESIDENT, in reference to these minutes said—I may say we were in a very unfortunate position. The Secretary (Professor Lebour) was unable to be present. We had no agenda of the business to be discussed, no accounts or statement of accounts. Therefore we could not complete the work of the Council in the way we anticipated. That is the reason the Committee meeting was adjourned to York. In the meantime we appointed Mr. M. Walton Brown Secretary *pro tem.*

PROPOSED JOINT MEETING AND EXCURSION WITH THE CHESTERFIELD AND MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

The PRESIDENT—I made a suggestion to Mr. Howard, the Secretary of the Chesterfield Institute that we should have a joint excursion—that is, the Midland and Chesterfield Institutes should meet and go together to some place of interest, to be decided upon mutually by the two institutes. For that purpose he has consulted the President of the Chesterfield Institute, and I have the following letter from him :—

CHESTERFIELD AND MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

CHESTERFIELD,

January 31*st*, 1891.

Joseph Mitchell, Esq.

President of the Midland Institute

of Mining, Civil, and Mechanical Engineers,

Barnsley.

Dear Sir,—I have informed our President (Mr. Jackson) of the suggestion you made to me verbally at Newcastle, that our two institutes should hold a joint meeting and excursion some time between now and the next Federation meeting. Mr. Jackson thinks favourably of the proposal and desires me to write asking you to be kind enough to send me your suggestion in writing for the consideration of our Council at their next meeting to be held probably on Wednesday, 25th February.

I may mention that the date on which our next General Meeting in ordinary course falls due, is Saturday, 11th April. It will be convenient to know about what date would suit your institute for the proposed joint meeting, and it would be advisable to nominate a committee of two or three or more from each institute to meet in Sheffield to agree upon arrangements.

I am, dear Sir,

Yours faithfully,

W. F. HOWARD.

The PRESIDENT—The Council will be pleased to know the views of members on the question. The Council have taken the matter into consideration, and have suggested a committee, if it meets with the approval of members that we should have a joint excursion.

Mr. W. H. CHAMBERS (Denaby)—I think it is desirable that these excursion meetings should be arranged if possible to see what is doing in other districts, particularly in South Wales, and South Staffordshire, where we have not yet had an opportunity of visiting the extensive operations going on, the new winnings which are being made in South Wales, and the generally bigger way of doing things than we are used to in this district. I think it would be well if an excursion could be arranged to see what they are doing, and to pick up a few wrinkles; whenever these meetings and excursions are arranged we have a very good attendance. I think that is one of the primary objects of the Institute—to endeavour to acquire knowledge in that way. It is particularly beneficial and interesting to the younger members of our Institute, who then have opportunities of seeing work in progress which they would not otherwise enjoy. I think those are two districts it is very desirable we should see.

Mr. A. B. SOUTHALL—A combination of the two institutes would be very much more satisfactory. Judging from past experience the difficulty has been to get a sufficient number of gentlemen connected with mining to visit any district. As a member of the Chesterfield Institute, I know they have been most successful in carrying out excursions. There is no doubt that for the younger members of the Institute it is desirable to get up excursions, whereby they can gather experience, which they could not obtain in this district. In every district you see coal

mining carried on in different forms. Circumstances which are adapted for one particular district are not suited for another. Perhaps we have young gentlemen, members of this Institute, who, if they get an appointment out of this district, are somewhat at a loss. Therefore I think an excursion would be very advantageous, particularly to the younger members.

The PRESIDENT—Is it your pleasure that we form a joint excursion?

It was unanimously agreed that a committee be appointed to meet a committee from the Chesterfield Institute, with a view of making arrangements for the proposed meeting and excursion.

DISCUSSION ON MR. R. MILLER'S PAPER "ON THE COAL-FIELD ADJOINING BARNSLEY."

Mr. HEDLEY—I should like to ask Mr. Miller if he knows the quantities or probable quantities of water to be dealt with in pumping from any of the shafts he names; and also as to the thickness of the seams, whether he can say where the sections have been taken?

Mr. MILLER—About the quantity of water in the pit I need perhaps to correct something that was in my paper. I said that Pindar Oaks had water from Darley Main, Martin's Main, and perhaps Smithies. I find it only has water from Darley Main and Martin's Main, not from Smithies at all. I mentioned further on that Mount Osborne might be used for pumping, but that pit is entirely disconnected with Pindar Oaks. There is no need of pumping there. The quantity of water cannot be very great, having only that from Pindar Oaks, Darley Main, and Martin's Main. It cannot be difficult to get it. I cannot say what the number of gallons may be, but a great deal less than I have seen pumped at other places. I find the shafts at Pindar Oaks are not 9 feet but 10 feet 6 inches, and they are 10 yards apart, so that there may be some widening and some water dealt with well enough. There was some talk of someone going to sink at Mount Osborne. I do not know whether there is anything in it or not, but these two places are quite distinct, one is independent of the other. There has never been the slightest hole made through. It is not connected with the Agnes Pit, at Pindar Oaks. You have the water from Darley Main and Martin's Main, and having got it out I believe you would find there would not be water below the Barnsley Bed. When once the water is dealt with to the Barnsley Bed it is done for ever. You will agree that below 226 yards there is no more water.

Mr. HEDLEY—You cannot say whether Porter's old workings are connected with Darley Main or Martin's Main?

Mr. MILLER—I do not think they are.

Mr. HEDLEY—Can you say what quantities were pumped from Darley Main, Martin's Main, and Pindar Oaks, when they were working?

Mr. MILLER—I don't know?

Mr. A. B. SOUTHALL—To my mind it is hardly a question of water; it is where Mr. Miller has taken his sections and thicknesses of coal. We all know that the Swallowwood coal and the Lidgett coal vary in thickness considerably. If Mr. Miller has been taking sections of this coal at one particular place he might have got that thickness. I should like to ask if he has taken it at several places?

Mr. MILLER—I have taken it chiefly off the sections published with Mr. Nevin's paper.

Mr. A. B. SOUTHALL—I think these coals vary much in thickness in different localities.

Mr. MILLER—They are given here as sunk through at Barrow and other places. I have taken them off these sections.

The PRESIDENT—Mr. Kell's sections.

Mr. W. HOOLE CHAMBERS—There is a seam spoken of as the Fenton Seam, given as being 260 yards, and the thin coal 315 yards. We are working the Fenton coal. It is just 30 yards above the thin coal, but it is not 8 feet thick, or anything like it. It is only 3 feet 2 inches, and in that thickness there are two bands of dirt—certainly not very thick ones—1 inch and 2 inches. But there is no 8 feet of coal there. I simply mentioned that as we have begun to work the seam.

Mr. NASH—I should like to ask Mr. Miller whether, in giving us this paper, he has taken into consideration whether it would not be cheaper for any enterprising individuals to sink through a virgin field, so that they have not these volumes of water to deal with, to put their shafts through where the Barnsley Bed is solid, so that you have no fear of any pressure from water in the old workings standing against you at all? If the thing was to be dealt with practically, that would be the most satisfactory way of dealing with it from an engineering point of view at any rate. Dealing with a lot of water standing in old workings is very difficult, and the possibilities of the Pindar Oaks workings being connected with other collieries in the district are so great that, once commenced, you would never know when you had got rid of the water or what pressure you would have coming on. With respect to the different seams, the Fenton Seam with us is divided into two seams—one 2 feet 11 inches and the other 3 feet, with 3 feet of dirt between the two. But it is a very local seam and one which I cannot think can be relied on at all as being of much value, near Barnsley, because no two sinkings of the district agree as to the thickness of the seam or the dirt between them, or the quality either. The Thorncliffe thin coal also varies very much in the higher portion of the district, both in quality and thickness, so that in speaking of it, in an unproved field like this, I think it is almost premature to give the thickness as 4 feet 6 inches, because when sunk through a little to the east at Wombwell Main it did not prove to be anything like this thickness. The Silkstone coal is a variable one, and as far as reports have been given to us of the sinking at Wombwell Main they are not so satisfactory as to encourage anyone to put down shafts in an unproved field. There is no doubt if the supremacy of Barnsley as the centre of the coal-producing district is to be maintained it will have to be proved in that district at no distant date. To put the Silkstone thickness

down at 5 feet 2 inches is wide of the mark. If it had been put at 4 feet, seeing that the farther we get east from workings of the Silkstone and Dodworth Colliery the thinner we find it, it would have been more satisfactory. Even in that colliery they have not more than 4 feet in the easterly workings in the Gawber district.

Mr. MILLER—With the band in?

Mr. NASH—5 feet 2 inches is mentioned here, and the statement is misleading. If you say it is that with a band of 14 inches of dirt we know what to expect; but 5 feet 2 inches is a wide margin and, to those who do not know the district, misleading. Certainly we have to thank Mr. Miller for bringing the subject before us and opening the discussion, but for my part I should certainly not be in favour of carrying out the scheme proposed in this paper.

Mr. THIRKELL—I should like to know where Mr. Nash is going to get his virgin Barnsley coal in the neighbourhood of Barnsley? I am not aware of many square yards about Barnsley where he would find the Barnsley Bed. It would only be a little barrier left between two royalties. If he can tell us of the virgin coal-field in the neighbourhood of Barnsley it would be valuable information.

Mr. HEDLEY—It may not be virgin coal-field, but there are collieries where they have not the water to contend with. Take for instance, the Oaks Collieries, that might be sunk down and yet you would not have to contend with an enormous body of standing water.

Mr. J. E. CHAMBERS—I understood a pillar was left at Day House Colliery with the intention of going through to the lower seams.

Mr. HEDLEY— I cannot say, but at present the matter is for a capitalist more than for a scientific institution.

Mr. SOUTHALL—Mr. Miller read his paper to put on record his views on the coal seams in the district. He has given us the best information possible under the circumstances. He does not ask us to sink a shaft, but gives the information and is desirous it should be on record in the Transactions. I think the information may be of value some day. Those who wish to spend money will be able to prove Mr. Miller correct or not in the future.

Mr. ANDREWS—I have had some little to do with coal mining in the past and have thought a little on this question. The paper brings forward valuable information which may not be available at present, but it strikes me in course of time a period will arrive when the information will be most valuable. As we work deeper and deeper the cost will be greater, and the question will come whether it is cheaper to go to greater depths, following the dip of the coal, or to tap some of the beds left intact, as suggested in the paper. I do think in the future, looking at the rate at which coal is being consumed, and the thick coal being worked, we shall come to the time when we shall be glad to work 2 feet 6 inches instead of 8 feet Barnsley Bed, and then this information will be valuable. I think it is desirable that the thing should be investigated in the Barnsley district. It is a question not only for capitalists but also for mining engineers to ascertain with accuracy the true depths in the neighbourhood of Barnsley of these various beds.

Mr. TEALE—I think a great deal of credit is due to Mr. Miller for giving us his ideas on this question. Barnsley has been a celebrated place, but Barnsley must not stand still; if action is to be taken it can only be done by the scientific and engineering skill of the district so far investigating it as to warrant a certain amount of expenditure by those who have got the capital. Capitalists want something to go upon; only by some little encouragement would they be induced to deal with this matter. If Mr. Miller's ideas are correct he seems to be pretty confident of the power of sinking through these existing mines, tubbing the water, and getting the lower seams, and, as I gather, he thinks it would be beneficial to the Institute. It is for the mining engineers of this Institute, who are so well posted in the geology of the district, to pass their opinion on the possibility of the object or not. Mr. Miller's object would be gained if sufficient interest could be evoked to lead the capitalist to put down his money, to go down to it, and if it turned out a success he would reap the benefit.

Mr. MILLER—I was asked if you could get tubbing to tub back the water at 200 yards. You could put the tubbing down in sections, each complete in itself. Mr. Chambers knows what they are. At a great depth they might put in fast top tubbing and then begin afresh.

Mr. A. B. SOUTHALL—It appears that it is a question whether this water should be dealt with, as Mr. Miller says, at Pindar Oaks, or, as Mr. Nash says, at a place some distance on the rise. It is not necessary that it should be sunk in a virgin Barnsley coal-field. It might be sunk through an old working of the Barnsley Bed, where it is at a shallow depth, not far from Pindar Oaks. The new sinkings would have to be so arranged and constructed that you should be in a position to win the coal at a mile at least on each side of the pit bottom. There is no doubt coal does exist under the Barnsley Bed in various thicknesses, but I am like Mr. W. H. Chambers, who said they varied in thickness. They do vary in thickness in that district. The deeper you get the thinner the Silkstone Seam. The only seam they consider workable at Wombwell Main is the Parkgate Seam; their excuse for not working the Silkstone Seam is that it is very thin. It suggests that they may be on the edge of a swilley or in disturbed ground. In the near future it will be a serious question for colliery owners and mining engineers to consider how, with a rapidly diminishing coal-field, a rapidly increasing market is to be met; when the time comes they will have due regard to Mr. Miller's paper, and be thankful to him for calling attention to these seams below the Barnsley Bed. As to the accuracy of the figures, I am not prepared to agree with them.

Mr. W. H. CHAMBERS (Denaby)—I fully agree with Mr. Miller that it would be cheaper to tub the water back where any quantity is to be encountered in sinking, providing there is none to be met with in the workings. Mr. Miller will remember it was suggested at the Leeds meeting that he should try to get particulars as to thickness of tubbing and the depth of the water-bearing strata in the Barnsley district, that he could lay before this meeting. I should be glad to know if he has obtained such information?

Mr. MILLER—I have no information about the depth of tubbing in the Barnsley district, but, as I said before, if at a depth of 176 yards you wanted to put tubbing in you need not tub the whole, but by putting in close topped tubbing, you could make two or three different sections. It makes tubbing very simple when you can tub it off at different points.

The PRESIDENT—But this is a colliery that has been worked out, and the only foundation to stand upon is a round pillar which, when you square it, is 4 yards on each side, so that the whole system of strata is fractured, and you could not make close tubbing.

Mr. HEDLEY—If the Kind-Chaudron system of sinking and tubbing was used (as at Marsden Colliery), it would be possible to enlarge the shafts, to sink lower and put the tubbing in from below the Barnsley Bed.

The PRESIDENT—But you could not put in close tubbing in sections.

Mr. A. R. SOUTHALL—We have an instance of putting in four or five pieces of tubbing at different distances. We tubbed 40 yards or 50 yards and then sank 70 yards, and without water. We again found water and had to put in more tubbing. There are four or five lengths of tubbing in the shaft, but we had to put a pipe connecting them all to the top length, the pressure of water was so great; it was the only way of getting the tubbing to hold. It has been standing fifteen years and is good yet.

The PRESIDENT—That is in virgin strata.

Mr. SOUTHALL—Yes.

The PRESIDENT—Not fractured?

Mr. SOUTHALL—No.

Mr. HEDLEY—You cannot tell us the thickness?

Mr. SOUTHALL—I cannot, but it is over 100 yards. There are either four or five lengths, and they are connected by one pipe.

Mr. HEDLEY—It has been the common practice in the North of England to connect one section of tubbing with another.

Mr. SOUTHALL—I should think that there would always be left a sufficient quantity of coal to support the shaft bottom. They could not leave such a small area.

The PRESIDENT—I know it is in this case.

Mr. SOUTHALL—I agree with Mr. Miller that it would be possible to put in pieces of tubbing and tub the water back.

Mr. HEDLEY—I know a case in the Barnsley district where the shaft was sunk on a goaf and tubbing put in to keep the water back so far up the shaft. I suppose the same thing could be managed in other places?

Mr. W. H. CHAMBERS—The pipe was put in to take the air out of the shaft.

Mr. SOUTHALL—It was the only way we could keep it tight, and certainly the pressure was relieved; but whether it took the air out or not I could not say.

The PRESIDENT—It shows the effect of continuous pressure.

Mr. HEDLEY—I propose that the discussion now close, and that the hearty thanks of the Institute be given to Mr. Miller.

The PRESIDENT—That has already been done.

The discussion then ended.

DISCUSSION ON MR. THOMAS ANDREWS'S PAPER ON "THE ACTION OF TIDAL STREAMS ON METALS."

The PRESIDENT—The next business is the discussion on Mr. Andrews's paper. Professor Arnold and Dr. Sorby promised to come, and several gentlemen had been invited but have been unable to come. So far as I am personally concerned this is more a question for a naval engineer. It is a most interesting and useful paper, and I am sure redounds very much to the credit of Mr. Andrews, who must have taken an immense amount of trouble and time to ascertain the facts now put on record. There is no doubt that fresh water and sea water have different effects upon steel and iron, but to what extent from chemical, or electrical, points of view, I am not sufficiently advanced in this particular science to discuss it. But you will all agree with me, we are much obliged to Mr. Andrews for having put upon our Transactions such valuable information. I have done my best to bring gentlemen who are competent to judge of the value of this paper here to-day; I had hoped to have had Mr. Bryce Douglas, Engineer and Managing Director of the Naval Construction Company of Barrow, and some of his friends here, but, unfortunately, they have other appointments which they are bound to keep. I regret that my friends have not turned up to discuss, from a scientific point of view, the valuable paper given by Mr. Andrews.

Mr. ANDREWS—I may mention that for twenty years I have been engaged in investigating the effects of various colliery, salt, and other waters on iron, steel, and other metals. This paper contains the results of some of the observations that I have made. I do not think now that I should close the matter, because I have in contemplation a further paper for this Institute bearing on a similar subject. I think therefore it might be desirable not to discuss things in detail until all the facts are before us. At some future time I may be able to bring a second paper before this Institute. I have endeavoured in these researches to bring to bear all the scientific knowledge—small it may be—that I possess in endeavouring to ascertain the principle with regard to the action of various mineral waters on metals. As you are aware, it is an important subject not only for the marine engineer, in the construction of his vessels, but also to the bridge builder, now that steel is so largely used in the construction of bridges. It also applies to boilers and to metals used in collieries or in places where saline water is used. I hope to continue the investigation until I can show with accuracy the metal that most resists the action of this water, and also produce some material to prevent corrosive action. I have been long working it out, and hope to get something that will throw a light upon it. In the meantime I shall make known for the public benefit the results I have obtained. I have no monetary object in view. It is a love of scientific investigation, and with a view to reduce the injuries to our metallic structures, that has led me to work at this question. When I tell you that some steels corrode 25 per cent. more

than iron, you may understand what that may cost in a colliery. In a bridge it is a more serious matter; and in a steam vessel it means one-fourth more capital outlay than should be year by year. I hope to bring more facts forward on a future occasion.

Mr. NASH moved that the discussion be adjourned.

Mr. SOUTHALL seconded the motion, which was carried.

Mr. ANDREWS suggested that when he read his next paper it would be well if a dark room could be provided, so that he could illustrate by limelight some of the effects of corrosion.

The PRESIDENT said this should certainly be provided.

PAPERS READ BEFORE OTHER FEDERATED INSTITUTES.

The PRESIDENT—It is competent for any member to give notice that he intends to raise a discussion upon any paper which has been read in connection with any other Institute of the Federation. If any member wishes to give notice of any particular paper that he would like to raise a discussion upon, he should notify the Secretary a fortnight before the next meeting, so that it may be put upon the agenda paper.

A vote of thanks to the Chairman concluded the meeting.

MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD AT THE ROYAL VICTORIA HOTEL, SHEFFIELD, APRIL 11TH, 1891.

MR. JOSEPH MITCHELL, PRESIDENT, IN THE CHAIR.

The minutes of the last meeting were read and confirmed.

The following gentlemen were elected Members of the Institute, having been previously nominated :—

Mr. Dan Rylands, Colliery Owner, Rylands Main Colliery, Barnsley.
Mr. Chas. Hedley, Colliery Manager, Blackpark Colliery, Chirk, Ruabon.
Mr. Benjamin Maydew, Colliery Manager, The Lodge Colliery, Chirk, Ruabon.

N.B.—This being the date of the joint meeting with the Chesterfield and Midland Counties Institution of Engineers at Sheffield, the separate meeting of this Institute was held, *pro forma*, for the election of Members only, as above.

SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

ANNUAL MEETING,

HELD AT THE MASON COLLEGE, BIRMINGHAM, ON MONDAY, MARCH 2ND, 1891.

MR. HENRY LEA, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting and of Council meetings were read, confirmed, and signed.

The Report of the Council for the past year was read by the SECRETARY as follows:—

REPORT OF COUNCIL FOR 1890.

Gentlemen,—In making this, their twenty-fourth annual report, the Council consider that in many respects a profitable and successful year has been passed.

Six general and five Council meetings have been held.

Seven new Members and Students have been elected, two have died, three have resigned, and five have been struck off in accordance with the rules for non-payment of subscriptions, so that the membership roll contains three less than last year, and now numbers 119.

From a financial point of view the year has been very satisfactory, as the receipts have amounted to £122 0s. 6d., or £9 6s. 3d. more than the previous year, and the expenditure has only been £89 14s. 8d., which is £10 16s. less than the previous year; the bank balance has been, consequently, increased by £32 5s. 10d., and now stands at £311 17s. 2d. The amount of the subscriptions due is £59 6s. 6d., all of which will probably not be recovered, and there are, in addition, the books, models, plans, specimens, bookcase, etc., at Mason College, which are not taken into consideration.

Considerable time was spent in the early part of the year in generally revising the rules and suiting them to the circumstances of the time. They have been issued in the improved form, and will no doubt be appreciated by the members.

The Council sincerely congratulate you upon carrying the scheme of federating the members as a body, instead of continuing the unsatisfactory arrangement of having only about one-third of your number members of the Federated Institution of Mining Engineers.

This has necessitated an increase of the annual subscription from one guinea to one and a half guineas, but the advantages gained far more than compensate. Only those, and they have been far too few, who have attended some or all of the Federation meetings which have been held at Sheffield, London, Edinburgh, Nottingham, and Newcastle-on-Tyne, can fully understand the benefits, instruction, and pleasure to be derived from the united gatherings of the several institutes, and the visits to the important works and mines and places of interest which have been thrown open in each district for inspection. The Federated Institution will hold its summer meeting in Birmingham, and it behoves the members of this Institute, upon whom the responsibility will fall, to give it a right loyal welcome, and a reception equal, if not superior, to that of the other places named.

At the annual meeting, the President, in his inaugural address, gave an excellent *résumé* of the mechanical engineering operations of the South Staffordshire Mines Drainage Commissioners, which was so highly thought of that the Commission, with the permission of the Council, published it for circulation amongst its members. The President, in the same address, pointed out, and practically illustrated, the importance of condensation as applied to winding engines.

Mr. H. W. Hughes, at the August meeting, read a very exhaustive and practical paper upon "Safety-Lamps," showing that recent experience, in actual working, had exposed defects that up to this time had not received attention.

Other communications had been made by Mr. Wallis, upon "Mechanical Telephones, and Electric Lighting and Transmission of Power," and by Mr. Summerskill, upon "An Automatic Fire Alarm and Heat Indicator."

Instead of having papers read at the two last meetings of the year, the President kindly conducted the members over, and fully explained the plants at, the Birmingham Central Tramways Company's electrical charging station and the cable tram depôt.

Your thanks have been duly and formally tendered to the Tramway Company for the opportunities and facilities.

Your hearty thanks are again due and hereby tendered to the authorities of Mason College for the accommodation they have provided.

In conclusion, the Council would strongly urge the importance of individual effort in furthering the interests of the Institute, by reading papers, securing new and qualified members, and attending the meetings as often as possible.

South Staffordshire and East Worcestershire Institute of Mining Engineers.

Dr. Treasurer's Account for the Year Ending December 31st, 1890. Cr.

	£	s.	d.
Bank Balance	279	11	4
Subscriptions received	116	11	0
Bank Interest	5	9	6
	£401	11	10

	£	s.	d.
Secretary's and Reporter's fees	50	0	0
Post Cards, Wrappers, and Stamps for Letters, Circulars, and Transactions for year	6	0	6
Expenses in connection with Federation Meetings (Sheffield and London) and Excursion to the Tram Depôts	4	16	0
Audit Tea, Wine for Visitors' Dinners, and fees to waiters at Annual Dinner...	5	2	6
Telegrams, Porterage, etc.	0	16	0
Shipway's for Printing Circulars, etc.	4	1	0
Waterlow & Co. for Lithos for Transactions	1	18	6
Dudley Herald for Printing Circulars and Transactions for 1889	15	17	8
Binding of Transactions	0	18	0
Bank charges...	0	4	6
Balance in Bank	311	17	2
	£401	11	10

Balance Sheet, 1890.

Liabilities.

	£	s.	d.
Fees due to the Federated Institution	21	0	0
Balance	350	3	8
	£371	3	8

Assets.

	£	s.	d.
By Cash at Bankers...	311	17	2
Subscriptions due	59	6	6
	£371	3	8

This is exclusive of considerably more than £100 worth of property, for which no credit is taken.

Examined and found correct, 19th February, 1891.

Signed, Daniel Rogers, William H. Whitehouse, } Auditors.

It was proposed by the PRESIDENT, seconded by Mr. WHITEHOUSE and unanimously resolved—"That the Report, Treasurer's Accounts, and Balance Sheet be adopted."

ELECTION OF OFFICERS.

The SECRETARY having read the report of the scrutineers of the voting for a President and officers for the current year, the following elections were unanimously approved:—

PRESIDENT.

John Williamson, Esq., Cannock Wood, Hednesford.

VICE-PRESIDENT.

W. F. Clark, Esq., Rowley Station Colliery, Dudley.

NEW MEMBERS OF COUNCIL.

W. Fairley, Esq., Beaudesert, Rugeley.
T. T. Fisher, Esq., Walsall.
Thomas Pasfield, Esq., Wellington Road, Dudley.
H. C. Peak, Esq., Walsall Wood Colliery, Walsall.
R. S. Williamson, Esq., Cannock Wood, Hednesford.

In vacating the chair, the retiring PRESIDENT (Mr. Henry Lea) said:—The year during which I have been President of this Institute—an honour which was conferred upon me by you, and which I very much appreciated—to-day comes to an end. And in looking back upon it I cannot do otherwise than see that my shortcomings have been numerous enough, and that there are many things which I could wish to have done for the benefit of the Institute which have not been done; but, at the same time, I hope you will accept my assurance that I have done my best for it. As we have a good deal before us at this meeting I shall not occupy your time with many remarks, but shall conclude now by conducting to the chair the new President (Mr. John Williamson), whom, I am sure, we shall all welcome most heartily.

The following gentlemen, who had been duly nominated, were elected Ordinary Members of the Institute:—

Mr. Robert Twigg, M.E., Hednesford.
Mr. H. G. Graves, Assoc. R.S.M., London.
Mr. John Yates, M.E., London.
Mr. Percy G. Poole, F.R.G.S., M.E., Klerksdorp, South Africa.
Mr. Henry Dennis, A.M. Inst. C.E., Ruabon.
Mr. David James, M.E., Ruabon.
Mr. Stephen H. Terry, Hednesford.
Mr. W. H. Greenwood, Birmingham.
Mr. E. J. Bailey, Birmingham.

Mr. WILLIAMSON then took the chair, and delivered his inaugural address as follows:—

PRESIDENTIAL ADDRESS.

By Mr. John Williamson.

Gentlemen,—You have conferred on me a great honour by electing me President of this Institute, for which I beg sincerely to thank you. I confess I feel some diffidence in undertaking such an important office, and I feel great trepidation in following those who have so ably presided in the past.

I will, however, do my best, and use my best endeavours and the best of my abilities to fulfil the duties of the office to which I have been elected.

In addressing you I feel that I shall address many amongst you of large and varied experience in connection with the working of coal and other mines. I shall, under the circumstances, endeavour to briefly touch upon subjects connected with mining, and some of those which were contemplated for study and discussion at the formation of this Institute. In an address on such occasions as this there is no time to enter into details of the subjects within my reach to-day, but I am afraid I shall have trespassed on two or three subjects, and must ask for your indulgence. Many of us are aware of the great improvements which have taken place in mining since the formation of this Institute, and I can imagine there are few members who have not been largely benefited by the works of the Institute. Valuable papers have been read from time to time on various subjects in connection with mining, and such work has largely contributed to the improvements in mining within recent years.

At the present time the facilities for getting mining knowledge are greater than ever. The federating of the mining institutes throughout the country and the concentration of mining knowledge will greatly assist those who are inclined to avail themselves of such provisions.

One of the great changes in the working of mines is the apparent safety to the workmen. This alone is a sufficient proof of the usefulness and humanism of the various mining institutes. Mining now, as compared with mining formerly, is safer and more healthy, and you may depend upon it, if you provide for safety in the mines, you also provide for the economical working of the mines. It is a fact that the duties of the mining engineer are as different as possible from what they were formerly. The different subjects, scientific and otherwise, which are so essential for study in connection with mining are more numerous. There are few professions combining so many different sciences as that of colliery management, and if a colliery has to be properly managed, it is absolutely necessary for the manager to possess a working knowledge of the principal subjects which has to guide him in his everyday work. Formerly the colliery managers (and clever men, too) had to content themselves with the rudiments of mining.

A successful manager now must possess a general knowledge of geology, sinking, winning and working of mines, ventilation, mechanics as applied to mining, and

chemistry as applied to mining, and many more subjects. To attain such knowledge as this requires properly trained minds. There are numerous colleges and schools of mines in the country where much valuable knowledge on mining may be learnt, and there are valuable works treating on mining, but it is well known that theory itself will not enable a manager to properly work a mine. The art of mining must be practically learnt in and about the mine. A practical knowledge of mining cannot possibly be got in the college or office; it must be got by daily and hourly inspection of the mine, and occasional visits to the mine will not qualify a person and give him the requisite knowledge to enable him to safely and economically manage a colliery.

A mining engineer certainly ought to possess some knowledge of geology (I presume there are few mining engineers who neglect this now), as the rule of thumb work of fixing shafts on unproved ground will not do at the present day. Mining speculations are to a great extent based upon geological reports; besides, a knowledge of geology is necessary for the proper exploration of the mines, and it will assist in dealing with faults and the different strata.

SINKING OF SHAFTS.—A great many of the difficulties which were formerly connected with this branch of mining have disappeared. The numerous and valuable inventions and appliances, which are within the reach of the mining engineer, have made sinking with the practical engineer comparatively easy and less expensive. The gin for sinking purposes has had to give way to the modern steam engine, and the old-fashioned pumping arrangements have been replaced by the modern pump, pulsometer, and other excellent appliances. The ventilation of sinking shafts is much simplified and more efficient. By the use of small fans the air can be forced down pipes or boxes so as to continually keep the shaft bottom free from powder smoke, etc., or compressed air in small quantities is very effective in shafts.

Where inflammable gas is likely to be met with, the use of the electric (incandescent) light hung from 10 to 20 yards above the shaft bottom will be found of great service; indeed, such a light under any circumstances is worth so much per yard in sinking. At the present time we may safely say there is no limit to the depth of mining, large shafts, large roads, viz., intakes and returns, with efficient ventilating appliances, and, if necessary, refrigerators will remove many of the difficulties which may naturally arise and be expected to arise in working at greater depths.

In connection with the working of a colliery with safety and efficiency there are several primary requisites to be secured, and the most important of these are:—1st, good roomy shafts; 2nd, the very best appliances for ventilation; 3rd, the best and most suitable mechanical appliances; 4th, the selection of practical, intelligent, and disciplined officials.

Some of the crucial points in connection with mining have to be dealt with after the shafts have reached the required depths; practical engineering will at this point have to be applied; the mining engineer will have to find the structure and thickness of the coal to be worked, and the direction of the end or face of the coal, together with the angle the seam is lying at; and it will be necessary to prove the nature of the roof and floor or bottom of the seam.

As soon as the mining engineer has satisfied himself on the various points, he will then have to consider the mode of work most suitable: the size of the different pillars for the protection of the shafts and roads will require careful consideration; and here he will have to form some idea of the number of divisions or districts, and the most suitable mode of working the mine, and in doing so it will be absolutely necessary to make proper provision for ventilation. If a mine has to be worked on modern principles, a system of haulage ought to be provided for in the laying out of the workings. To properly carry out all this work will require much practical knowledge and foresight, as any mistake or error of judgment at this stage may seriously prejudice the working of the colliery and create permanent costs.

If there is one thing in connection with mining requiring more attention than another, it is ventilation.

There are many amongst us who can bear testimony of the usefulness of the furnace as a means of ventilating mines, and at the present time furnace ventilation is strongly advocated. Some of the largest collieries are ventilated by furnaces: many of these collieries have been working for sixty to seventy years or more. We have on record the superiority of fan ventilation, at certain depths, over furnace ventilation; with the former we have almost complete control over the ventilation, and with properly constructed fans the quantity of air can be arranged to suit the conditions of the mine. Some people may say they are getting all the air possible for the fan to get and not getting sufficient to ventilate the mine, but this may not be the fault of the fan; the cause of this may be in the mine, or the fan may have been put down considerably under its work. You can only expect certain sized fans to do a certain amount of work, and it is worth the consideration of the mining engineer, whether he should not put down a fan with considerable reserve power, and instead of running the fan at a high speed, run at a moderate speed, and thus reduce the liability of accidents to a minimum. It is said the fan is liable to be stopped by accident due to some breakage in connection with the machinery, but it can be safely said that fans, 40 feet by 12 feet, have been run for eighteen years without any stoppage from breakage, and these fans have produced from 180,000 to 190,000 cubic feet of air per minute.

We have recently heard that all the pure air a collier has is that which he takes into the mine with him. At collieries on Cannock Chase, over 400,000 cubic feet of air per minute is exhausted from the mine, and at many other collieries large volumes of air is continually being exhausted from the mines.

To minimise stoppages through accident, a prudent manager will provide duplicate engines, and will also duplicate certain parts of the motion of the engine, and he will also make provision in the upcast shafts to utilise the steam used by the engine as a steam jet in case of a long stoppage to the fan. The Royal Commission on Accidents in Mines, in a summary of the most important subjects dealt with in the report, say, "Volumes of air sufficient for the ventilation of even the most extensive collieries are capable of being passed through the workings by means of properly constructed furnaces, or by mechanical contrivances such as are already in action at most of the

collieries; where furnaces are used they should, in preference, be in connection with dry and deep shafts and should be provided with dumb drifts."

Formerly it was the custom to calculate the quantity of air which was considered necessary for the ventilation of the mine, by taking the number of men and horses employed in the mine and to apportion it; and within recent years such calculations have appeared in some works on colliery management. The Coal Mines Acts completely ignores this mode of calculation, as the first general rule is very explicit; it says, "an adequate amount of ventilation shall be constantly produced in every mine, to dilute and render harmless noxious gases to such an extent that the working places of the shafts, levels, stables, and workings of the mine, and the travelling roads to and from those working places, shall be in a fit state for working and passing therein."

There has to be no suspension of the ventilation, whether men or horses are in the mine or not. If all the working places of the shafts, levels, stables, and working places of the mine, and the travelling roads, etc., have to be ventilated in accordance with the Act, it is clear, proper means will have to be provided for the purpose. To illustrate what is meant here, take a longwall work, say 400 yards in length, with roads 44 yards apart, and that in each road there is a door or doors for the purpose of forcing the air to the far end of the work; this was, and is now, the custom at many collieries; slides on the doors, or small openings (sometimes dangerous things), are provided as a scale to allow a portion of air to pass for the ventilation of the roads. It can easily be seen that if this arrangement in frequent scaling is carried out to any great extent the quantity of air at the far end of the workings would be considerably reduced. This can all be remedied by forming a counter head or road, parallel with the intake road, and by properly splitting and carrying the air up and down the roads; this applies to longwall work. What I want to point out is, the loss of air at all the openings in doors, etc., and instead of having nearly the full quantity of air which is going into the district, there is only a portion left to sweep the face, fast ends, wastes, etc., of the work at the far end. If the Mines Act has to be complied with all roads, fast ends, etc., must be ventilated; and by a system of cross-roading, the roads can be ventilated by coursing, or running the air up and down, and if the roads are kept free from obstruction there is no difficulty about it.

A small piece of sheeting hung across the face of work will throw a portion of the air into the roads and cause it to travel down one road and along the cross road, or counter head, till it reaches the next road, striking a sheet hung across the road, it will be driven up the next road on to the face of the work. The face of work is more or less throttled by falls of coal, cogging, etc., so that a portion of air will naturally take the easiest route, viz., up and down the roads. Some people have a crude idea about ventilating wastes, fast ends, cavities in the roof, and vacant places; they consider the current of air passing along the face of work sufficient to ventilate the places named without any attempt to divert it and cause it to circulate in those places. Such places left unventilated or unfenced would certainly be a violation of the Coal Mines Act. A practical manager, who understands ventilation

and the splitting of the air, will not be guided by plans published by theorists showing the ventilation of colliery workings. Much more might be said on ventilation, the splitting of air, etc., but time will not permit.

FITTING UP OF SHAFTS.—Great improvements have been made in drawing shafts. All shafts are cased or lined, and shafts of larger dimensions have been provided. Wire conductors have taken the place of wood or iron, and when properly fixed and weighted, are safer and more economical.

ENGINES.—Considerable improvements have been made on all classes of steam engines. The winding engine of the present day is much superior for the work it has to do as compared with the engine of forty or fifty years ago. It is of the greatest importance to have suitable engines for winding and drawing coal, as the time allowed for this work is so limited. In selecting an engine for winding the chief points to be borne in mind are :—1st, the position of the engine house with the shaft ; 2nd, the nature of the work it has to do ; 3rd, the speed and power required. The automatic cut-off gear is worth consideration. There are engines of all forms in the market, but considering the work a winding engine has to perform, the most advanced form of engine will in the end be by far the cheapest. Then, in connection with the winding engine, there is an important appendage, viz., the brake. According to the Mines Act, an adequate brake has to be provided. Hundreds of lives are in the hands of an engine worker daily, and their safety depends greatly upon the adequacy of the brake.

HAULING ENGINES.—There are various types of hauling engines ; at many collieries there may be seen some of the most improved engines.

In the selection of a hauling engine, special care ought to be taken to see that the engine is suitable for its work. There is nothing more destructive to ropes, chains, and rolling stock than a badly constructed engine and one under power.

The economical working of a colliery depends so much on haulage that this subject deserves more than ordinary attention. There are so many different forms of haulage in vogue now, that before any one system is adopted it is necessary to understand the form of the roads and the contingencies of the mine. Practice has proved that in the ordinary working of a colliery it is not necessary to fix hauling engines in the mine as formerly. At many collieries hauling engines are fixed on the surface, and the ropes taken down the shafts, and for distances of one, two, or more miles into the workings. This applies to tail or endless rope haulage.

At the present time there is no limit to the capabilities of the wire rope for transmitting power for haulage, pumping, and other work. Compressed air and electricity are used as motors for underground haulage, and under certain circumstances they may be more suitable than rope haulage, but up to the present time I am not aware of the superiority of compressed air and electricity over rope haulage.

It is almost impossible to say too much about the usefulness of winding and hauling ropes now as compared with twenty or thirty years ago.

BOILERS.—No boiler can be pronounced as the best for all duties, and each separate case should be judged on its own merits and the surrounding circumstances.

A boiler as a steam generator must combine strength and durability with economy in working. High pressure boilers are more economical than low pressure. Heavy firing and insufficient boiler power is most injurious. Boilers of the best make will yield to continual stoking and the opening of furnace doors.

TIMBERING OF THE FACE OF LONGWALL WORK AND ROADS.—For the sake of life and limb and economy, too, timbering of the mine ought to form a study of itself; timbering ought to be done under strict supervision, and if it has to be done efficiently, an uniform system must be adopted to meet the requirements of the mine; and to have this work properly carried out, trained workmen ought to be employed, and properly trained officials to inspect, and proper timber ought to be provided. The closing of roads and faces of work for want of timber, interferes with the ventilation of the mine, and sometimes to a dangerous extent.

BLASTING.—This is a matter requiring great skill, and ought to be in the hands of properly qualified men only; "restriction with judgment" should be the rule, and a prudent manager will see this carried out.

Formerly, there was but one explosive for use in the mine, but now we have many, and we have as many different opinions on the explosives to be used in mines as we have explosives. In some fiery mines, what are called flameless explosives are used, and have been where the atmosphere of the mine was charged with inflammable gas and dust. I should not like to express myself too strongly on this point, but I cannot help thinking that the use of some of the flameless explosives in fiery and dusty mines are highly dangerous. The question with me is, if the atmosphere of the mine is charged with dust and inflammable gas, viz., showing a halo or blue top on the flame, whether blasting ought to be allowed under such circumstances; to say the least, there is always danger where such a state of things exist, even without blasting. The use of flameless explosives in gassy mines is no doubt tempting to those who are prohibited from the use of ordinary blasting powder and are unable to supply sufficient air to render harmless noxious gases and remove the dust. The explosive properties of coal-dust is a question of great importance at present. Fifty or sixty years ago when the atmosphere of the mine, during working hours, was highly impregnated with dust, its inflammable and explosive properties were then unknown.

It is a fact that at this time there was much more dust floating about in the roads and working places in the mine than at present. This state of things was to some extent due to the mode of transit of the coal. Explosions from coal-dust alone were unknown. If coal-dust in itself is explosive, it is somewhat paradoxical at present.

It is admitted that if the atmosphere of some mines is charged with dust and is in juxta position to much flame caused by either an explosion from an accumulation of gas, or a blown-out shot, the flame will be augmented and the explosive force will be greatly intensified.

One of the remedies for explosions caused by a combination of gas and coal-dust is improved ventilation to prevent accumulations of gas near blasting operations.

SAFETY-LAMPS.—There are few subjects connected with mining received more

attention than the safety-lamp. Since the days of Davy, Stephenson, and Clanny, the safety-lamp has been of the greatest service; mining without a safety-lamp would be as languid as a steam engine without sufficient steam. The original safety-lamps were always subject to great abuse; formerly there were no locks on lamps, and the oil reservoir was charged through a small tube, with a screw plug in it; the unscrewing of the lamp, where safety-lamps were ordered to be used, was frequent and caused many explosions. When the careless collier wanted to light his pipe, he either removed the top of the lamp or caused the flame of the lamp to impinge on the gauze and easily sucked it through the gauze. After the lamps had been in use for many years, a new lamp with lock and key came into existence, but even the lock and key did not prevent the lamp from being tampered with.

Since the passing of the Mines Regulation Act of 1872 great improvements have been made in the safety-lamp to meet the requirements of the mine; much more air travelling at greater velocities is required for ventilation, and like many improvements in mining the safety-lamp has been improved and made much safer. Many of the modern safety-lamps give a superior light to the original lamps, and in their construction more safety is secured. The severe experiments the modern safety-lamp has been subject to within recent years leaves no doubt as to its safety; and there are large numbers of safety-lamps as perfect as it is possible to make them, and to reach this state of perfection in the modern lamp the principles of safety contained in Davy, Stephenson, and Clanny lamps have had to be embodied.

The numerous safety-lamps all have their advocates, and to select a suitable lamp for all purposes is a matter which ought to be left in the hands of practical men, as there are several points in the construction of a safety-lamp requiring much practical knowledge.

1st.—In the construction of a safety-lamp there ought to be precision and as few parts as possible.

2nd.—The best principles of safety, and not too heavy.

3rd.—The construction ought to be such as to give the best light possible.

4th.—Efficiency in the locking arrangements, so that the dangers of the original lamps are locked up and put out of the reach of workmen.

5th.—Only skilled men be allowed to clean, test, and examine the lamps.

6th.—Proper arrangements and good discipline in giving out and receiving lamps after being in use.

COAL-CUTTING MACHINES.—If we have to go with the times it is necessary to adopt mechanical appliances as much as possible. There are several types of coal-cutting machines in use now. Before the adoption of a coal-cutting machine it is necessary to consider the thickness of the seam, the structure of the coal, and the contingencies of the mine.

The Gillott and Copley is more applicable to thin than to thick seams, on account of the form of the machine, the coal being cut by rotation. The cutters are fixed on the periphery of a revolving disc, which limits the cutting or holing to about 3 feet 6 inches, but this depth of cut in thick and cross-grained coal seams will not provide for a proper percentage of large coal.

The Baird machine is similar in construction to the Gillott and Copley, with the exception of a projecting arm or jib in the place of a revolving disc. The cutters on the Baird machine are fixed on strong links, and are caused to revolve round a studded wheel on the engine and around another wheel at the end of the projecting arm or jib. This arm can be set to hole to any desired depth up to 5 feet or 5 feet 6 inches, providing the strength of the machine is arranged accordingly. Such a machine is more suitable for cross-grained coal than the Gillott and Copley.

There are in use in America electrical coal-cutters, which are said to work well, and are simple in construction and easy to move about.

Then we have the Stanley Heading Machine. The coal is cut by rotary cutters fixed on arms. This machine will cut from 12 to 15 yards, 5 feet 6 inches diameter headway, in twenty-four hours, and would do much more if the coals could be removed fast enough The motive power in these cases is compressed air, which also ventilates the places of work.

Hydraulic and electric motors are used for various purposes in the mines, and can be taken for unlimited distances, but it is a question now how far electricity can be used with safety in mines. Electric motors for coal-cutting machines would be attended with a certain amount of danger, even in non-fiery mines. Before electric cables are taken into the workings for any distance, and until complete safety is secured, it would be well to consider the safety of the mine.

THE COLLIERY MANAGER.—There are few people outside of collieries who understand what the duties of a colliery manager are. Compliance with the provisions of the various Acts of Parliament alone requires much thought, skill, and judgment. If a manager fails to comply with any of the numerous provisions of the Acts he renders himself liable to fines, imprisonment, and the loss of his certificate.

A colliery manager's duties are continuous. The changes of the barometer and thermometer have to be watched night and day; the ventilation of the mine has to go on without interruption, and he must be prepared to deal with any emergency, and, as every practical man knows, there are few mines free from almost continual movements due to the extraction of the coal and subsidence of the roof and lifting of the floor, etc., thus rendering it necessary to have strict day and night supervision over the whole of the mine; and it must be borne in mind that though a manager may appoint who he chooses to perform the various duties he cannot relieve himself of the responsibilities. This goes to show the necessity of a manager selecting practical and trustworthy men, but to get such men is most difficult in some districts. The men most fitted for competent men ought to be the practical colliers, but whether it is bashfulness or want of inclination for such work it is difficult to say, but it does appear to be worth the consideration of the steady collier whether he should continue to work at the coal face all the days of his life or prepare himself for a work more suitable for old age.

The number of colliery officials have been largely increased since the Coal Mines Act came into operation, and there is at almost every colliery much greater facilities

for the miners improving themselves than formerly, and properly speaking there never ought to be any difficulty in having properly trained men to act as deputies or competent men.

In conclusion, there are many subjects beyond the compass of my address left untouched. If time had permitted they might have been referred to, but considering I have already trespassed on your time and patience, I must leave them to be dealt with by those more able than myself, and hope some of the members of this Institute will give us their views and the benefit of their experience on modern mining and appliances in all forms.

I daresay many of us often think after the completion of some important work in connection with our duties we may sit down and rest, but experience has taught us, every day furnishes new matter for thought, reflection, and study, and if we have to keep our position and hold our own—to go on with the times—we must not push the new matter to one side, but deal with it, and continue to look as far into the future as possible. Safety and economy greatly depends on this.

I know of nothing requiring more foresight than colliery management.

At the conclusion of his address, the PRESIDENT moved the following vote of thanks to the retiring President:—"That the best thanks of this Institute be given to Mr. Henry Lea for the able, kind, and courteous manner in which he has conducted the business of this Institute during the past year.

Mr. COLLIS seconded the resolution, which was carried unanimously.

Mr. LEA acknowledged the resolution. If, during his term of office, he had been able to afford any information, or to bring any satisfaction, or to do anything in the interest of the Institute, he could only say that it had afforded him very much pleasure.

Upon the proposition of Mr. H. C. PEAK, seconded by Mr. R. S. WILLIAMSON, a vote of thanks was accorded to the members of the Council for their services during the past year.

On behalf of the Council, Mr. CLARK acknowledged the resolution, and also personally thanked the members for the honour they had done him in electing him Vice-President of the Institute.

STEAM LOOP AND SEPARATOR.

A working model of the steam loop was exhibited and described by Mr. LEA.

Mr. SCOTT wished to know whether any use was made of the exhaust steam from the engine; and secondly, would the same thing apply with the steam loop if the engine was placed above the level of the boiler?

Mr. E. B. MARTEN and Mr. H. W. HUGHES also addressed some questions to Mr. Lea.

Mr. LEA said, with regard to Mr. Scott's question as to the exhaust steam from the engine, the steam loop does not deal with the exhaust steam from the engine. It does not profess to do so. I have seen a model in which the whole of the steam from a small model engine was sent back into the boiler against the boiler pressure, but it is but a model, and in practice it would assume such proportions that I think the expense of installing the apparatus would be too great to justify the result. Mr. Scott enquired what would happen if the engine were placed above the boiler level. Well, in that case the water, separated from the steam, would run back to the boiler of its own accord. Mr. Marten asks a question, the first part of which I am not able to answer off-hand. "What power of engine will it require to do the work which the steam loop does in returning the water to the boiler, and of the two, which is the more economical?" I should say that the engine would be the less economical one. As regards Mr. Hughes's question as to economy, there were some trials made on board of three steamboats in the North of England, each fitted with a steam loop. According to the report which I have received, No. 1 loop was not so skilfully applied as the other two. They all went long voyages, and, on their return, the chief engineers reported that as regarded No. 1 there was a saving of 6 per cent. in the coal consumed. On No. 2 there was a saving of 14 per cent.; and on No. 3 there was an equal saving, showing that in cases where the steam loops have been put in properly there has resulted a saving of 14 per cent. in coal. I am unable to give you details of the difference in the application of the loops.

Mr. LEA then read papers descriptive of the Electrical and Cable Tramway Depôts, which had lately been visited by the members.

THE BIRMINGHAM CENTRAL TRAMWAYS COMPANY'S ELECTRICAL TRAMWAY DEPÔT.

By Henry Lea, Past-President.

On Thursday, the 2nd of October last, some of the members of this Institution visited the electric depôt of the Bristol Road Electric Tramway, and on Thursday, the 11th of December, some of the members visited the depôt of the Cable Tramway. On both occasions, by the courtesy of the Directors and officers of the Birmingham Central Tramways Company, Limited, every facility was afforded for the members to examine and to be informed upon the many points of interest belonging to the respective systems.

This paper is intended to be a descriptive account of what was seen on the first occasion referred to, with a few remarks upon the working of the system.

The electric depôt occupies a space of about 265 feet by 120 feet.

Beginning with the fuel from which the energy is primarily derived, the following are some of the particulars:—

The coal store is 37 feet by 30 feet, and holds about 100 tons of coal.

The boilers are two in number. Each boiler generates enough steam to give 100 brake horse-power at the fly-wheel rim of the engine, which is supplied by it. Each boiler is of the multitubular type, 12 feet 6 inches long, and 7 feet 6 inches diameter, with two internal furnace tubes, each 2 feet 4 inches diameter, and 70 boiler tubes, each 3 inches diameter. The gases pass through the furnace tubes to the back of the boiler, then return through the 3 inch boiler tubes to a smoke box at the front, and thence pass through brick flues surrounding the boiler shell to a Green economiser placed in the flue leading to the chimney stack. The working pressure is 120 lbs. per square inch. The boilers are fed either by an injector or by a Worthington pump.

The chimney stack is circular, 110 feet high, and 4 feet diameter inside at the top.

The engines are two in number, each capable of giving 100 brake horse-power at the fly-wheel rim. Each engine is compound, non-condensing, with Paxman patent automatic expansion gear to the high pressure cylinder. The cylinders are respectively 12¾ inches and 20 inches diameter, with a stroke of 24 inches. They lie side by side and are coupled to cranks at right angles. The fly-wheels are 8 feet 6 inches diameter, and 17 inches wide, and overhang the outer bearings. The speed is about 100 revolutions per minute. Each engine and boiler is intended to do the whole work of charging the accumulators, the second engine and boiler being used as a reserve.

The dynamos are two in number, and are duplicates of each other. They are Elwell-Parker machines, built for a continuous current, shunt wound, each giving 500 ampères at 120 volts, or 60,000 Board of Trade units. Each is driven by a link belt 16 inches wide, running in a belt race lined with glazed bricks. The speed is about 540 revolutions per minute. Slides and screws are provided for tightening the belts when in motion. The belts run with the slack side above, so as to give a better grip of the pulleys. The whole work upon each dynamo consists in charging accumulators for twelve cars, and, in addition, some fixed accumulators from which the depôt is lighted, and from which an 8 unit workshop motor is driven. The engines and dynamos are in one room, about 48 feet by 29 feet, which also contains the main switch board, provided with two Cardew voltmeters, two 600 ampère ammeters, and main and other switches. A 5 ton overhead travelling crane commands the whole of the machinery.

The distributing switch room is 25 feet by 12 feet, and has 32 sets of apparatus for measuring and regulating the current to the 32 shelves of the accumulator platforms in the charging shed. It also has other regulating apparatus for the use of the battery room. The regulation is effected by means of resistances in connection with rheostats.

The charging shed is 72 feet by 62 feet, and contains 4 hydraulic elevators, each having 8 shelves, capable of accommodating in all 32 sets of battery trays of 6 trays to a set, or 192 trays holding 8 accumulators in each tray, making a grand total of 1,536 accumulators upon the shelves at one time. 32 positive cables convey current from the distributing room to the 32 shelves, to which they were originally connected by sliding contacts, but now by insulated cables, of which the slack is taken up by weighted pulleys. The 32 return, or negative, cables are joined together, and go back to the dynamos as one cable. Hydraulic power is furnished by a set of hydraulic pumps and a hydraulic accumulator. The pumps are worked by a separate steam engine. Hydraulic valves enable the attendant to raise or lower each hydraulic elevator so that any shelf thereof may be placed on a level with the accumulator floor of a tramcar. The discharged accumulators are drawn from the car on to a vacant shelf by means of iron hooked rods, the hydraulic platform is then raised or lowered until it arrives at the right level, when the fully charged accumulators are pushed from the shelf which they occupy into the tramcar. As each tray of 8 cells is drawn on to a shelf, or pushed into the tramcar, an electrical connection is automatically established by means of spring contacts.

The running shed is 97 feet by 62 feet, and between each pair of rails is a continuous pit giving access from below to the mechanism underneath the cars.

The remaining portion of the depôt affords the following accommodation :—

Water tower, 30 feet high, supporting a cast iron tank, which holds about 10,000 gallons of water.

Fitting shop, 36 feet by 30 feet, with shafting driven by the 8 unit electric motor.

Smith's shop, the fan for which is driven by the aforesaid motor.

Furnace room for melting lead,

Men's room, stores, offices, urinals, W.C.'s, and lavatory, an underground rain water cistern, and an underground vat for oil.

The electric cars are 26 feet 6 inches long and 6 feet 3 inches wide. They carry 24 inside and 26 outside passengers. Each car rests upon two bogie trucks, one of which is the propelling truck, the other being merely a carrier. The accumulators are placed underneath the seats, and access to them is obtained by external teak panels sliding vertically underneath the windows. Each car carries 12 teak trays, in which are 96 cells, containing in all 960 negative and 864 positive plates, each about 8½ inches by 6¼ inches. The 8 cells in each tray are permanently coupled in series, and give 16 volts per tray. The trays are grouped three in series, giving 48 volts per group. The four groups are connected by insulated cables, with two driving and reversing switches, one at each end of the car. There are six positions of the driving switches, namely:—

1. Disconnection of the motor, and of every group of cells.
2. The four groups connected in parallel, giving 48 volts at the switch.
3. The groups in parallel, and connected to the motor, which then starts the car.
4. The groups two in parallel and two in series, giving 96 volts, and accelerating the car.
5. The groups two in parallel and two in series with the first two, making three in series, giving 144 volts, and still further accelerating the car.
6. The four groups in series, giving 192 volts, which is the full pressure.

The driving switch is so arranged that the driver can suddenly cut off from full power, but he cannot again obtain full power without going over the whole of the grades just described.

The motor is of the Elwell-Parker type, series wound, and propels the car at about eight miles an hour when revolving at about 640 revolutions per minute. To each car there is only one motor, and it drives the four wheels of one bogie frame only. It rests upon two bearings on one axle and one bearing on the other axle, the latter having a strong coiled spring between the motor frame and the axle box. The motor drives the two axles by means of double-purchase gearing, having helical teeth, all the wheels and pinions being steel castings. The armature revolves six times for each revolution of the tram wheels.

Other accessories are: a principal brake, retarding all the eight wheels at once, an auxiliary brake acting upon central drums on the two axles of the idle bogie frame, and two 16 candle-power incandescent lamps for lighting the car.

The service was started for public use on 24th July, 1890, and has been running fairly continuously ever since. The interruptions from snow were not more serious than in the case of other self-propelled tramcars. The system was under the inspection of the writer, on behalf of the Birmingham City Council, until December 31st, 1890, during which period the cars ran altogether about 55,000 miles.

Trial runs were made by the writer with instruments for measuring the electrical energy required, and other similar runs have since been made by the Tramway Company's officials. The following are a few particulars:—

A double journey is about 6 miles.

The time occupied was about 49 minutes.

The rising gradients in both directions amount in all to an elevation of about 194 feet.

The weight of the car is about 9 tons.

The electrical energy as measured at the motor terminals, estimated in foot-tons, was, for the double journey, 5,125 foot-tons.

The car was observed to just maintain its speed when running without electrical energy down a gradient of 1 in 112, representing a friction of 20 lbs. per ton of the weight of the car.

The distribution of energy is therefore approximately as under for the double journey:—

	Per Cent.
Travelling up gradients...	34
Friction along the whole route, at 20 lbs. per ton ...	49
Other losses	17
Total, being electrical energy as measured ...	100

The cars run about 350 car miles per day, or say 58 double journeys, requiring 5,125 foot-tons by 58 = say 298,000 foot-tons of energy, which is obtained by the consumption of about 56 cwt. of coal per day. Assuming that 4 lbs. of coal will give 1 indicated horse-power for 1 hour, the energy represented by the coal used is 1,380,000 foot-tons, and the efficiency as between the steam engine indicated horse-power and the electrical energy at the motor is 22 per cent. nearly.

This seems at first sight but a poor return, but in cost for fuel per car mile it is about the same as for the tramway steam locomotives.

The first set of accumulators was nearly worn out after the first five months of their use. This is rather less than the time which it was estimated that they would last, but considering the heavy demands for power which are inseparable from the running of new cars on a new line of tramway, the result so far may be considered to bear out fairly well the anticipations of the company as to the life of accumulators for tramway purposes.

Time and careful observation will afford data for more elaborate calculations; meanwhile these are the results of the data which I have at hand, and I must express my indebtedness to the chairman of the Public Works Committee, and to the chairman and the engineers of the Tramways Company for their kindness in allowing me to place them before you.

THE BIRMINGHAM CENTRAL TRAMWAYS COMPANY'S CABLE TRAMWAY DEPÔT.

By Henry Lea, Past-President.

The depôt of this tramway is at Hockley, and from it are worked two endless steel wire cables for hauling cars to and from Colmore Row on the one side, and to and from Handsworth on the other side.

Beginning as before with the combustion of the fuel from which the motive power is obtained, there are six steam boilers of the Galloway type, 24 feet long by 6 feet diameter. Each has two furnace tubes 2 feet 4½ inches diameter, united behind the bridges into one oval flue, which is furnished with water pockets and Galloway tubes. The working pressure is 80 lbs. per square inch. They are fed with water by two donkey feed pumps and two exhaust injectors. The water passes through a feed-water heater. The smoke is led into a chimney stack 5 feet 6 inches diameter inside at the top, and 110 feet high.

The engines are two in number, each capable of working the whole traffic, one being held in reserve. They are horizontal non-condensing engines, and are fitted with Jefferies' patent automatic expansion gear, by means of which they are efficiently controlled. The cylinders are 24 inches diameter, with a 48 inch stroke, and are steam jacketed. Each fly-wheel is 15 feet diameter and 2 feet wide, and has a powerful steam brake, by means of which it can be quickly stopped in the event of an accident to the rope. The two crank shafts are 9¼ inches diameter in the bearings and are placed in line with an intermediate shaft, which, by means of a clutch, either engine can be made to drive. The intermediate shaft carries a spur pinion 5 feet 4⅛ inches diameter, gearing into the first spur wheel of 13 feet 11⅛ inches diameter, which in its turn gears into the second spur wheel, also 13 feet 11⅛ inches diameter. Standing near the pinion and looking beyond it at the wheels one sees that the two spur wheels turn two shafts, upon the right-hand ends of which are two cable pulleys, 10 feet diameter, for working the cable to and from Birmingham, while upon the left-hand ends are two similar pulleys, 13 feet 4 inches diameter, for working the cable to and from Handsworth, the respective speeds being about 6 miles and 8 miles per hour. The cable pulleys can be separately disconnected by means of clutches provided on the shafts of the spur wheels. When the clutches are in gear all the cable pulleys are driven by the gearing. On the right-hand, or Birmingham side, the rope is drawn on to the lower side of the cable pulley nearest to us. After bending round this pulley in an upward direction it passes downwards to the lower side of the second or farther cable pulley. Bending round this in an upward direction it passes horizontally rearwards to the top of a tension pulley, after passing round which it passes under the floor on its outward course to Birmingham. The tension pulley being canted a little out of upright, the cable clears the driving pulleys on its outward journey. The Handsworth cable is similarly dealt with by the cable pulleys on the left-hand side.

The tension gear consists of the tension pulley already mentioned, which is mounted upon bearings carried upon an iron truck which travels upon a railway about 120 feet long in the tension room, the truck being pulled, so as to tighten the cable, by a tension rope passing over a fixed pulley and kept taut by adjustable weights hanging within a well sunk for the purpose. The temporary stretch of the cable is taken up by the tension weights which rise and fall as the length of the cable varies under the varying load imposed upon it by the cars. The permanent stretch is taken up by winding the spare portion of the tension rope upon a winch fixed upon the travelling truck. The V-grooves of the cable pulleys are lined with compressed beechwood. The cable lies upon the beechwood.

Having now described the course of the cable within the depôt, we will follow it outwards to Birmingham, and will then return to the remaining points of interest at the depôt. From the tension pulley the cable passes alongside without touching the driving pulleys as aforesaid, and thence along a tunnel or "rope lead" measuring about 156 feet in length. At the further end of the tunnel, and underneath the street tramway lines, is an enlarged chamber containing four cable pulleys 8 feet diameter turning on inclined axes. Of the four pulleys, two are the outward and inward pulleys for Handsworth, and two for Birmingham.

Following the Birmingham cable, we find it passing from its 8 feet pulley in a direction inclining upwards, until it arrives at the first carrier pulley, whence it proceeds for about 1½ miles, supported and guided by pulleys, placed usually about 28 feet apart, but closer when required by the curvature of the road. When it reaches the Colmore Row terminus, passing over the last carrier pulley, it descends to an inclined guide pulley, whose diameter equals the distance between the centres of the two tracks, and then returns, underneath the return track, supported and guided as before described, to the bottom of the first driving pulley within the engine room, already described.

On its journey out and home it passes points of interest. First, on emerging from the depôt, it finds itself underneath, but considerably to one side of the central slot rail, and out of reach of the grippers of the cars. Gradually, the track and its central slot, following a curved path, enable the grippers of the cars to get underneath the cable, and, by means of the mechanism referred to further on, to grip the cable firmly. Then the sharp corner at the top of Snow Hill attracts attention. Here the guide pulleys, 17 inches diameter and 6 inches deep, are placed no more than 3 feet apart, there being upwards of 50 of them under the two tracks to guide the cables round this one corner. In order to clear the pulleys, the grippers of the cars have to hold the cable away from the adjacent pulleys; and in order to prevent the grippers from being bent by the strain, they are provided with rubbing pieces, which rub against and derive support from fixed rubbing faces placed underneath the central slot rails and just above the guide pulleys, following the curve of the curved tracks. The radius of the curve is 45 feet, upon a rising gradient of 1 in 20–28, and the design of the work here required the utmost care. For the whole

length of the Colmore Row curve the ground had to be excavated for a width of 15 feet and a depth of 7 feet 6 inches in order to accommodate the walls, girders, guide pulleys, and chambers of access, which so sharp a curve demanded.

The writer has several times visited the chambers below this curve and has watched the grippers rounding the curved row of pulleys, holding the cable off each pulley for a moment and then allowing the cable to return to one pulley after another, and a very interesting sight he found it to be.

Returning now to the depôt the following matters require notice :—

"Barring" engines are used for slowly turning round the main engines, when necessary, by means of worms and worm-wheels, and the latter throw the worms out of gear as soon as the speed of the main engines exceeds that of the barring engines. The barring engines have 6 inch cylinders and 7 inch stroke.

Overhead of the machinery is a 6 ton travelling crane commanding the whole area of the engine room, which is 50 feet long by 40 feet wide.

The cable renewing gear is placed at one end of the boiler house. It comprises a pair of small vertical steam engines driving, by means of spur gearing, a drum upon which is wound the old cable as it is withdrawn from the route. The free end of the old cable is attached to and draws in the new cable, uncoiling it from a paying-out drum placed near the winding-in drum.

The running shed is about 180 feet by 62 feet, and has six lines of rails, with pits for giving access to the mechanism underneath the cars. A steam locomotive is kept in steam in this shed for the purpose of hauling the cable cars into and about the depôt after they have left the cable and back again to the main route when required. The whole of the tracks within the depôt have to be provided with central slots to allow the grippers to pass, although within the depôt there is no cable for them to take hold of.

The repairing shed is 120 feet by 44 feet. There is a large open yard, and all necessary offices and other conveniences.

In the running shed the construction of the gripper was seen. In principle it may be said to consist of a sliding wire gauge upon a large scale, the stem of the gauge passing downwards through the central slot of the roadway, and the measuring jaws of the gauge taking hold of and firmly gripping the cable. Force is applied to the slide of the gauge by means of a suitable hand lever. That part of the gauge in which the slide works is firmly attached to the underside of the bogie frame of the car.

The hand lever is made in two parts, a principal lever and an auxiliary lever. The movement of the principal lever in one direction causes the gripper to hold the cable firmly, and the movement in the other direction causes it to relax its grip, but never to open the gripper jaws so wide as to allow the cable to escape sideways from them. When, however, a terminus is being approached, and it becomes necessary to let go and get away from the cable altogether, the movement of the auxiliary lever lowers the gripper jaw so far that the cable can easily escape sideways, and then, the track being laid to swerve a little to one side at that spot, the gripper permanently departs from the cable.

At Hockley the cars have to pass from the Birmingham cable to the Handsworth cable, and *vice versa*. When a car travelling from Birmingham to Handsworth arrives at the Hockley pulleys, the gripper having been opened wide as described, and having got free of the Birmingham cable, the car is allowed to run on by its momentum until the gripper arrives in position for being closed upon the Handsworth cable, when the auxiliary lever is first raised to confine the cable within the working limits of the gripper, and the principal lever is then moved so as to cause the gripper to grip the cable and carry along with it the car. At each terminus a similar process is gone through, but the car has to be drawn back by hand or by horse-power so as to cross over from one track to the other.

The grippers are situated underneath an axle of the bogie frames, so as to be always free in the slot rail even when rounding curves, whereas the hand levers are well to the front of the driving platforms. Connections between the hand levers and the grippers are made by rods and bell cranks having sufficient freedom in their joints to permit of the necessary motion of the bogie frame in relation to the body of the car when rounding curves.

In constructing the roadway, of which the central slot is continuous from end to end of the tramway, some means had to be adopted to hold the sides of the slot in position. For this purpose bent yokes of steel of a T-section were used, having supplementary yokes riveted to them for strengthening purposes. The yokes are placed 4 feet apart, and descend into a continuous cavity of semi-oval section, formed of concrete underneath the roadway, within which cavity the cable and the grippers travel, the guide pulleys and carrying pulleys being mounted upon carriages, accessible from the street by means of removable iron covers.

The steel wire cable consists of six strands each of 19/15 steel wires laid around a hemp core. The breaking strength of the cable is 33 tons, or 95 tons per square inch of the cross section of the wire contained in it.

I am indebted to Messrs. Pritchard & Kincaid, the engineers of this tramway, for the loan of the excellent drawings which hang in the room, and for many of the particulars which I have placed before you.

ELECTRIC LIGHT FITTINGS, ETC.

Messrs. John Davis & Son, of Derby, exhibited their special electric light fittings for colliery use, electric miners' lamps, improved surveying instruments, etc.

APPARATUS FOR PREVENTION OF OVERWINDING.

The members then proceeded to the basement of the College, where an apparatus for the prevention of overwinding, etc., had been specially erected for their inspection.

SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

GENERAL MEETING,

HELD AT THE MASON COLLEGE, BIRMINGHAM, ON THURSDAY, APRIL 2ND, 1891.

MR. JOHN WILLIAMSON, PRESIDENT, IN THE CHAIR.

The minutes of the annual meeting, held on March 2nd, 1891, were read, confirmed, and signed.

EXHIBIT OF OLD MINING IMPLEMENTS (PLATE XIV).

Mr. W. BEATTIE SCOTT exhibited some old mining implements, and in describing them said—It will probably strike you that they are somewhat antiquated. I have a few notes that were made by the son of the owner of the colliery where they were found which may interest you. I might first draw attention to the fact, which will be known to members of the Institute, that at Pelsall the coal lies at a very shallow depth indeed, and there still remains a portion of what was known as Pelsall Common, or Pelsall Heath, unenclosed, but there are portions which have been enclosed under the Enclosures Acts. I mention this to show what is the age of the workings in which these old implements have been found, for the hedges and the timber have all grown over the enclosed lands, and all signs of old shafts or workings of any kind have disappeared; but in the re-opening of this colliery, now called the Heath Colliery, is found the Four-yard coal, which, to bring it nearer home to the members, may be divided into two seams with which they are more familiar—the Deep and the Shallow. They run together at a line passing through one end of the Pelsall Hall Colliery. At a little more than 100 yards distance there are 11 yards of strata between the two seams. You can see the thin edge of the shales taking a wedge shape there, and this, of course, is not strange to members who are accustomed to underground work. But in the re-opening of this colliery by Messrs. Hough & Son they began to work the Deep coal, and their drivings were in the Deep coal. Frequently the Shallow seemed to have been worked in some modified form of pillar and stall, only leaving such portions as would be required as a support to the roof; and in driving the new roads in the Deep coal they would occasionally strike a gutter which had been cut from the Shallow workings into the top of the Deep coal. (There may be two reasons for the non-working of the Deep coal of this vein. After all it would seem that the water-line remained at the top of the Deep coal, and they were never able to lower

that water.) Then there has been a rush of Shallow coal "shutt" or "gob," and such an article as this has rushed down. (Fig. 1.) You will easily, perhaps, judge for what purpose it has been used. But you will notice that there are four holes which look as if they had been bored and bars put in for supporting the coal on this, and that this is nothing more than a sledge for drawing the coal to the bottom of the shaft; it was necessary to attach something to this to draw it, and you will recognise in this implement (Fig. 2) what is known as a "dog-hook," the handle is simply a branch as it has been cut from a tree, and the cross handle seems to be a bit of dressed oak. This "dog-hook," then, was used for the purpose of drawing the sledge. I find from the note by Mr. Hough, that frequently old shafts were found only 3 feet 6 inches in diameter, and some were square. To show the means they had of drawing water in those days: in the bottom of these shafts have been found old cheese boxes, into which the water was scooped and then raised to the surface. It is considered that the Shallow coal must have been in operation at least 200 years ago, and then only at the small depth of 12 yards. You have heard of wooden shovels; here you have one before you. (Fig. 3.) I have a further note upon another discovery. (Fig. 4.) This bottle rushed into the Deep coal new drivings, and the owner makes these remarks, which I have no doubt will meet with the approval of the Institute. "There were two classes of men in those days as miners—total abstainers and beer drinkers, as one of the bottles was filled with water and the other with strong beer." Fig. 5 is evidently the handle of a winch, which formed the winding machinery of these early days. This type of winding capstan may still be seen at work along the outcrop of the seams of the Black Country. It struck me when I saw these implements that they might interest the members of the Institute, and I asked Mr. Hough's permission to have them sent over for your inspection. Since these implements were in use, mechanical engineering has made great advances.

The PRESIDENT, in proposing a vote of thanks to Mr. Scott, said the ancient mining tools which were before them enabled them to form some idea of the difficulties that miners had to deal with in days gone by. They could form a very good idea of the number of tons of coal that could be got out of a pit at that time. He thought such relics were deserving of proper attention, and if they could be placed in some museum it would be a very good thing indeed. He had much pleasure in moving a vote of thanks to Mr. Scott for the instructive and interesting manner in which he had described the implements.

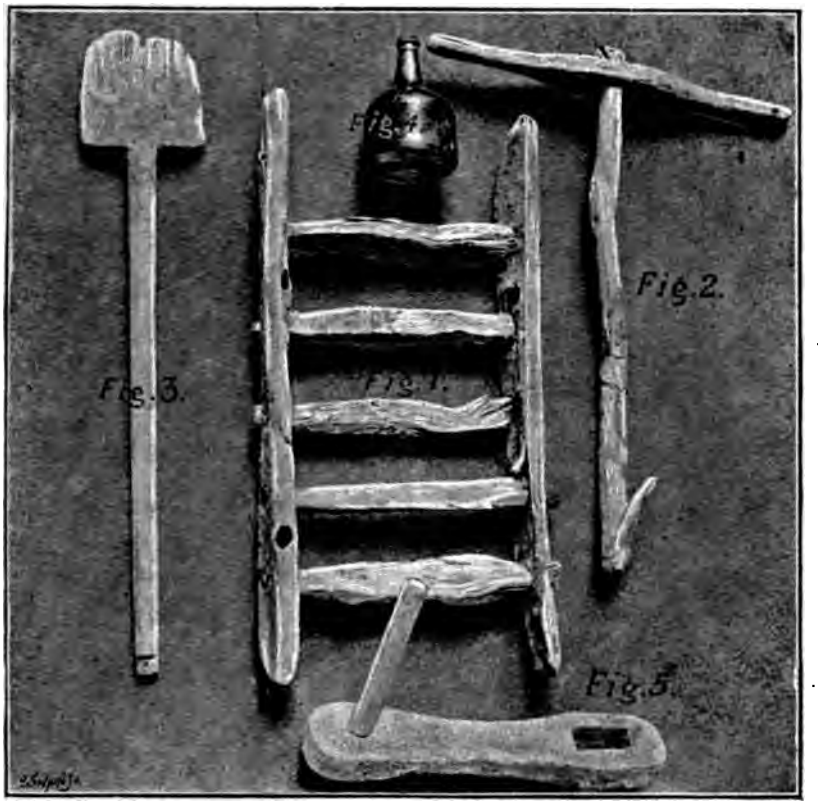
Mr. SOPWITH seconded the motion, and it was carried unanimously.

The vote was acknowledged by Mr. SCOTT, who hoped that the owners of the relics might be induced to present them to the Institute.

Mr. CLARKE said that a bottle, similar to the one exhibited by Mr. Scott, had been found at Brettell Lane. It was not exactly the same shape, probably being more modern; but there was also a small earthenware cup and a pipe found with the bottle, all in perfect order.

A paper upon "Colliery Explosions" was then read by Mr. W. FAIRLEY, F.G.S.

To illustrate Mr. W. Beattie-Scott's remarks on "An Exhibit of Old Mining Implements".



REFERENCE.

FIG 1. SLEDGE.
" 2. DOG-HOOK FOR SLEDGE.
" 3. WOODEN SHOVEL.
FIG. 4. BOTTLE.
" 5. WINCH HANDLE.

NOTES ON COLLIERY EXPLOSIONS.

By W. Fairley.

The following remarks, relating to the cause and results of colliery explosions, are founded upon the reports of H.M. Inspectors of Mines for the different districts of Great Britain:—

The tabular matter accompanying these observations has been compiled from the statistical information given in the reports for the last forty years.

For the year 1889 the writer has given an account of each explosion which occurred throughout the twelve inspection districts; it has been thought that there can be no better way of obtaining practical lessons on the cause and prevention of explosions than by carefully going through these reports, because they contain the matured and carefully-written opinions and advice of twelve expert engineers, based upon great experience in mining operations in all their various forms.

The writer will proceed at once to give details of the different explosions which occurred in the year 1889.

East Scotland District.—One man lost his life by an explosion of fire-damp by going into the goaf with an open light.

West Scotland District.—There were four fatal explosions, resulting in the death of five persons; the first occurred on the 23rd July at Bothwell Park Colliery, causing one death; this was caused by firing a shot. The inspector states he considers that the shot ignited a feeder of gas, which continued to burn unnoticed for some time until it ignited an accumulation of fire-damp. The second was at Lanemark on the 12th October, when one man was killed by taking a naked light into a working place in which it was stated gas had not been seen before. Two men lost their lives at Meiklehill Colliery on the 4th November in consequence of "a sudden outburst of gas at the face;" the workmen there had safety-lamps, but in the adjoining workings "naked lights," hence the explosion. This was considered a contravention of General Rule 8, which states: "When it is necessary to work the coal in any part of a ventilating district with safety-lamps, it shall not be allowable to work the coal with naked lights in another part of the same ventilating district situated between the place where such lamps are being used and the return air-way." The last fatal explosion during the year occurred on the 20th December at Barwood Colliery, by a naked light coming in contact with an accumulation of gas above the timber in the horse road. The fireman stated he had examined the place previously and had "passed below it with his naked light on his head half an hour before the explosion."

There were thirty-five non-fatal explosions, resulting in the injury of fifty-four persons.

The discipline appears to have been bad in this district, and there were numerous prosecutions against the officials for contravention of the rules.

The inspector says in his report:—"Many of the explosions of fire-damp would have been prevented had the General or Special Rules been observed either by the sufferers or by the officials."

NEWCASTLE DISTRICT.—A fatal accident was caused by an explosion at Dipton Colliery on the 21st March, but the most serious was that at Hebburn on the 4th November, which caused the death of six persons. In the opinion of the inspector this accident was due to a "blown-out" shot, he says: "It is my opinion that the accident, whereby these men lost their lives, was caused by the flame blown out from this 'fast' shot, assisted by any small quantity of fire-damp that might be present."

DURHAM DISTRICT.—There were no explosions of fire-damp, but a very singular accident occurred at Brancepeth Colliery, which caused the death of three men, by an explosion of coal-dust while engaged in cleaning out a large bunker. They had four large oil torch lamps with them, and as soon as they commenced to disturb the large accumulation of fine dust the explosion took place.

YORKSHIRE AND LINCOLNSHIRE DISTRICTS.—There was one explosion in this district causing two deaths. It was at Whitwood in the Haigh Moor Mine, the place had been "weighting;" naked lights were used in the mine; the inspector considers "that a sudden irruption of gas had taken place, which passed along into the main gateway, and then ignited at the candle of a boy who was taking three full corves up the gate." Safety-lamps have since been adopted exclusively throughout the pit. Two men were suffocated by going into fire-damp on the 17th June at the North Gawber Colliery.

MANCHESTER DISTRICT.—There were no fatal explosions during the year; three non-fatal explosions occurred, open lights being used in each case.

LIVERPOOL DISTRICT.—In the West-Lancashire portion of this district there were no explosions of fire-damp, but in the North Wales division, there were several non-fatal explosions, and one very serious explosion at the Pendwll Pit of the Brynmally Colliery, near Wrexham, by which 20 persons lost their lives. According to the inspector "there had been gross want of discipline as regards the opening and the locking of the safety-lamps in use at the colliery." The verdict at the inquest was that: "The explosion was caused by the accidental fall of the roof in Garston's jig up to the Nine Inch Seam, which caused a sudden outburst of gas which was ignited where three men and a boy were supposed to be sitting with lighted open lamps, which in their opinion caused the explosion."

MIDLAND DISTRICT.—No fatality from explosions of fire-damp occurred in this district during the year, but there were a few non-fatal explosions, which for the most part, according to the inspector, took place for want of care and attention to the rules of the mine.

On the 20th December, a miner was suffocated by carbonic acid gas at the Hill Top Colliery, and on this account the manager was fined £10 for violating the first General Rule.

NORTH STAFFORDSHIRE DISTRICT.—An explosion occurred at Hyde Colliery on the 18th January, by which 23 lives were lost; death was caused by suffocation from after-damp, and the verdict of the jury was "accidental." The inspector in his report states that the coal-dust was the most dangerous element in this explosion, and that the loss of life was mainly due to its firing. He did not consider that meteorological conditions had any bearing on the explosion. He makes the note that there was a slight shock of earthquake that morning in Edinburgh two and a half hours before the explosion.

An explosion occurred at Chell Colliery on the 17th August, causing the death of three men. The explosion was due to the presence of gas only, and was not augmented by coal-dust; and according to the official enquiry, the ventilation was ineffective, and there was great blame to the management for the imperfect system of ventilation, and the careless way in which the work had been carried out. In this case the manager was heavily fined for breaches of the rules.

On the 16th October an explosion occurred at the Mossfields Colliery, causing a loss of 64 lives. At the inquest it was not satisfactorily decided how the explosion occurred, but the manager was censured, and the inspector states that the supervision exercised in the colliery was defective.

There were two non-fatal accidents in the district, both of which appear to have taken place on account of some defect in the underground ventilation.

SOUTH STAFFORDSHIRE DISTRICT.—There were seventeen explosions during the year in this district, none of them being fatal at the time, but four deaths afterwards took place from the injuries received. On the 31st of October at the Saltwell's Colliery, two men lost their lives by a sudden fall releasing gas and the air-current carrying it upon their naked lights, and thus causing an explosion. The inspector speaks of the "lax discipline," and "culpable recklessness" which occasioned some of these explosions. An explosion occurred on the 2nd December at the Sandwell Park Colliery. In the opinion of the inspector the cause was a heavy bump, producing an emission of fire-damp, which fired at the naked lights.

SOUTH-WESTERN DISTRICT.—Five deaths occurred from two explosions in this district. At Dean Lane Colliery, on the 27th January, an explosion occurred by which four men lost their lives; at the inquest the following verdict was returned:—"That the three men died from burns, and a fourth man from the effects of noxious gases, the result of an explosion of fire-damp, but how the gas accumulated the evidence did not show." Naked lights were in use at the time, but safety-lamps have since been adopted.

On the 9th July an explosion occurred at Cwmbran, causing the death of one man; this was due to the use of naked lights, the ventilation had been interrupted by the removal of a canvas sheet and gas allowed to accumulate. There were five non-fatal explosions, which occurred where lamps were not in use; in one case the examiner disobeyed orders in allowing naked lights, and he was punished for it

SOUTH WALES DISTRICT.—One life was lost in this district during the year by an explosion which took place at Lower Llanmorlais Colliery on the 25th February. The men were working with safety-lamps, but after the explosion the gauzes and bottoms were found apart. As the inspector says, this occurrence "showed the necessity for enforcing strict discipline in regard to the use of safety-lamps wherever they are used."

There were twenty-one non-fatal explosions, sixteen of which occurred where the mines were worked with naked lights. With regard to one of the explosions, that of the 22nd February, at Fernhill, it was maintained that a spark from the pick had kindled a blower of gas from the floor. In one case a collier had passed the fence in contravention of the rules. The inspector is of opinion that not one of the sixteen explosions would have happened if the collieries had been worked with safety-lamps. "Still," he says, "while undoubtedly safety-lamps are a great protection against explosions, their use will never prevent an explosion under every possible condition."

Such are the particulars as gathered from the Government reports of the explosions during the year 1889, but for 1890 the details cannot at present be given, as the reports have not yet been published, excepting as relates to the statistics, and the information contained in this, together with previous reports, enables the writer to give the following tabular results:—

In 1888 there were 49 lives lost in the collieries of Great Britain; in 1889, 138; and in 1890, 290.

Table I. shows the lives lost in each district by explosions alone for each of the past three years.

Fortunately, last year there were no lives lost by explosions in the South Staffordshire district.

I.—TABLE GIVING A COMPARATIVE STATEMENT OF THE LIVES LOST IN EACH DISTRICT BY COLLIERY EXPLOSIONS IN THE YEARS 1888, 1889, AND 1890.

No.	District.	1888.	1889.	1890.
1	East Scotland	2	1	5
2	West „	1	5	5
3	Newcastle	31	7	—
4	Durham	—	—	—
5	Yorkshire and Lincolnshire ...	4	2	2
6	Manchester	—	—	2
7	Liverpool	1	22	1
8	Midland	—	—	—
9	North Staffordshire	—	90	2
10	South „	2	4	—
11	South-Western	—	5	182
12	South Wales	8	2	91
	Total	49	138	290

The analysis above given of the explosions in 1889, taken in connection with the reports for previous years, enables one to conclude that they have occurred from the following causes:—

By shot-firing.
By driving narrow places in advance of the air-current.
By ignition of coal dust.
By workmen rambling about the mine from one place to another.
By waffing gas out.
By want of discipline, culpable negligence, and breach of the rules.
By placing scaffolds in shafts and leaving the parts below unventilated.
By making a sinking shaft a return.
By using Clanny and Davy lamps, which are known not to be always safe.
By disobedience to orders.
By gas coming off when the working face is weighted.
By defective ventilation.
By furnace ventilation.
By the use of naked lights where lamps should have been used.

Having ascertained the causes of colliery explosions, it is for colliery managers to see that the mines under their charge are conducted in such a way that these serious occurrences may be reduced to a minimum or as far as possible prevented; all that can be said in conclusion is—"Remove the cause and the effect will cease."

The number of lives lost by explosions, as will be seen by Table II., during the past forty years, is 9,055, and appalling as this is, it is only about one-half of the number that has been lost by falls of roof and sides.

During the last forty years the percentages of fatalities according to the three following heads, work out in the proportion:—

	Per Cent.
Explosions of fire-damp	21
Falls of roof and sides	40
Miscellaneous accidents	39
	100

Table III. shows the number of accidents for different periods under the three heads mentioned.

Table IV. shows the ratio of persons employed per life lost under the same three heads.

The tables show that mines are now more than twice as safe as they were forty years ago.

In no case do the reports give any encouragement to the theory of a connection between the vicissitudes of the weather and the occurrence of explosions of fire-damp; when an opinion is given by the inspectors it is generally against this theory. As a barometer, a body of fire-damp is more sensitive than anything else, and any

II.—TABLE SHOWING NUMBER OF DEATHS BY ACCIDENTS, AND THE RATIOS OF DEATHS BY THE ACCIDENTS TO THE NUMBERS OF PERSONS EMPLOYED IN AND ABOUT THE MINES UNDER THE PRESENT AND FORMER COAL MINES ACTS, NAMELY, FROM 1851 TO 1872, OF THOSE AT COAL MINES ONLY; AND FROM 1873, OF THOSE AT COAL, IRONSTONE, OILSHALE, AND FIRE-CLAY MINES, IN GREAT BRITAIN AND FROM 1874 IN IRELAND ALSO; THE PERSONS AND DEATHS ON PRIVATE BRANCH RAILWAYS AND TRAMWAYS, AND IN WASHING AND COKING COAL UNDER THE PRESENT ACT, NOT BEING INCLUDED. COMPILED FROM THE VARIOUS REPORTS OF HER MAJESTY'S INSPECTORS OF MINES.

	Deaths by Accident.					Ratio of Persons Employed to each Death.			
Year.	By Explosions of Fire-damp.	By Roof and Sides Falling.	By Miscellaneous Accidents above and below ground.	Total.	Persons employed above and below ground.	Explosions of Fire-damp.	Roof and Sides Falling.	By Miscellaneous Accidents above and below ground.	Total.
1851	321	327	336	984	216,217	673	661	643	219
1852	264	349	373	986	222,843	844	1,066	598	226
1853	214	370	373	957	229,468	1,072	620	615	219
1854	210	389	446	1,045	236,094	1,124	606	529	225
1855	146	407	402	955	242,719	1,662	596	604	254
1856	236	400	391	1,027	249,345	1,056	623	637	242
1857	377	372	370	1,119	255,971	678	688	692	228
1858	215	366	350	931	262,596	1,221	717	750	282
1859	95	399	411	905	269,222	2,833	674	866	297
1860	363	388	358	1,109	275,847	759	710	770	248
1861	119	427	397	943	282,473	2,374	661	711	300
1862	190	422	521	1,133	291,000	1,532	680	559	257
1863	63	407	337	907	299,000	1,834	734	887	330
1864	94	395	378	867	307,542	3,271	778	811	355
1865	168	381	435	984	315,451	1,877	828	725	320
1866	651	381	472	1,484	320,663	492	888	679	216
1867	286	449	455	1,190	333,116	1,165	742	732	280
1868	154	444	413	1,011	346,820	2,252	781	840	343
1869	257	466	393	1,116	345,440	1,344	741	879	310
1870	185	411	395	991	350,894	1,897	854	888	354
1871	269	435	371	1,075	370,881	1,378	852	999	345
1872	154	456	450	1,060	418 088	2,714	916	929	394
1873	100	491	478	1,069	512,199	5,122	1,043	1,074	479
1874	166	413	477	1,056	538,829	3,245	1,304	1,129	510
1875	288	459	497	1,244	535,845	1,860	1,167	1,078	430
1876	95	449	389	933	514,532	5,416	1,145	1,323	551
1877	345	448	415	1,208	494,391	1,433	1,103	1,191	409
1878	586	469	358	1,413	475,329	811	1,013	1,327	336
1879	184	426	363	973	476,810	2,591	1,119	1,313	490
1880	499	462	357	1,318	484,933	971	1,049	1,358	368
1881	116	450	388	954	495,477	4,271	1,101	1,277	519
1882	250	468	408	1,126	503,987	2,015	1,076	1,230	447
1883	134	469	451	1,054	514,933	3,842	1,097	1,141	488
1884	65	482	395	942	520,376	8,005	1,079	1,317	552
1885	341	439	370	1,150	520,632	1,526	1,185	1,407	452
1886	129	461	363	953	519,970	4,030	1,127	1,432	545
1887	149	470	376	995	526,277	3,532	1,119	1,399	529
1888	49	471	368	888	534,945	10,917	1,135	1,453	602
1889	138	465	461	1,064	563,735	4,085	1,212	1,223	530
1890	290	434	436	1,160	613,233	2,114	1,413	1,406	529
Totals ..	9,055	17,047	16,177	42,279	15,788,129				
Averages	226	426	404	1,057		1,743	926	976	326

warning that a ventilating engineer may receive from meteorologists outside cannot be of any practical use as regards danger from gas; so long as the manager can carry out the first General Rule of the Coal Mines Regulation Act, then he may

III.—TABLE SHOWING THE YEARLY AVERAGE NUMBER OF DEATHS CAUSED BY EXPLOSIONS OF FIRE-DAMP, FALLS OF ROOF AND SIDES, AND MISCELLANEOUS ACCIDENTS IN COAL MINES FOR FORTY YEARS, IN THE PERIODS UNDERMENTIONED:—

Years.	Explosions of Fire-damp.	Falls of Roof and Sides.	Miscellaneous Accidents.	Total.
One year ending 31st Dec., 1851	321	327	336	984
Ten years " " 1860	244	377	381	1,002
" " " 1870	227	416	420	1,063
" " " 1880	269	451	415	1,135
" " " 1890	166	460	402	1,028
Average for 40 years ...	226	426	404	1,057

IV.—TABLE SHOWING THE YEARLY AVERAGE RATIO OF PERSONS EMPLOYED TO EACH DEATH CAUSED BY EXPLOSIONS OF FIRE-DAMP, FALLS OF ROOF AND SIDES, AND MISCELLANEOUS ACCIDENTS IN COAL MINES FOR FORTY YEARS DURING THE PERIODS UNDERMENTIONED:—

Years.	Number Employed for One Man Killed by Explosions of Fire-damp.	Number Employed for One Man Killed by Falls of Roof and Sides.	Number Employed for One Man Killed by Miscellaneous Accidents.	Number Employed for One Man Killed by all the Accidents.
One year ending 31st Dec., 1851	673	661	643	219
Ten years " " 1860	1,008	653	646	245
" " " 1870	1,408	767	761	300
" " " 1880	1,795	1,069	1,161	425
" " " 1890	3,199	1,153	1,323	516
Average for 40 years ...	1,743	926	976	326

remain safe and contented. This, of course, is not always easy to do, from the peculiar circumstances of the ventilating arrangements, such as ventilating motor, size and depth of shafts, and conditions of underground roads.

The question is frequently asked—which is the best book to read on coal-mining? The answer may be given that for working mines safely the best book to study is the reports of H.M. Inspectors of Mines, and it is hoped that all mining officials and mining students will avail themselves of the vast amount of information which they contain on the safe working of coal mines.

The PRESIDENT thought there was a great deal in Mr. Fairley's paper that ought to be properly discussed, and he did not think they could enter into the discussion that day. He proposed that the discussion of Mr. Fairley's paper should be deferred until the next meeting.

Mr. SCOTT seconded the proposal. He said he should like to draw the attention of the Institute to one fact that had occurred for the first time in the history of mining in South Staffordshire: no life had been lost by an explosion of fire-damp in South Staffordshire during the past year. It might point to the fact that discipline was better, ventilation was better, and that mining knowledge had been largely improved.

The discussion was accordingly postponed until the next meeting.

APPARATUS FOR PREVENTION OF OVERWINDING.

A paper upon the "Apparatus for the Prevention of Overwinding," which was exhibited at the annual meeting, was announced to be read at this meeting, but as there had not been time to prepare large diagrams to illustrate the paper the reading of it was postponed until the next meeting.

Mr. FAIRLEY proposed the following gentlemen as Members of the Institute:—

Mr. William Riley, Rugeley,

Mr. W. E. Marples, Rugeley.

FEDERATED INSTITUTION OF MINING ENGINEERS.

GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,

JANUARY 21ST, 1891.

MR. T. W. EMBLETON, PRESIDENT, IN THE CHAIR.

The SECRETARY (Mr. M. Walton Brown) reported the proceedings of the Council meeting which had been held that morning.

The PRESIDENT said they had heard the report of the meeting of the Council, and he hoped they would approve of their resolutions. It was high time now that these alterations had been made in the conduct of the business of the Institution. The publication of the papers, read by members and others, was greatly in arrear. and other matters that ought to have been attended to many months ago have been neglected. It was hoped that, from the present time, a new era would commence in the history of the Federated Institution, and that in the future no person would have cause for complaint, and he trusted that they would approve the action taken by the Council.

The President's statement was received with acclamation.

Mr. J. B. SIMPSON (Blaydon) said, before they passed to the formal business of the meeting, he desired to propose a vote of thanks to their late President (Mr. John Marley). They were all aware that during the time he had been President, Mr. Marley had put all his energies into the affairs of the Institution, and they must all feel very sorry that his illness prevented him from being present on this day; they would all agree that this vote of thanks should be passed to Mr. Marley for his past services to the Institution during the time he was President, and that their sympathy with him in his severe illness should be recorded.

The PRESIDENT said he thought the proposal of Mr. Simpson did not require seconding; every one present would thoroughly agree with it, and every person would be the seconder.

This proposal was cordially adopted.

Professor MERIVALE then read his paper on "The Steam Loop and Separator."

THE STEAM LOOP AND SEPARATOR.

By Professor J. H. Merivale.

In proposing to read a paper on this subject, it was intended to have referred to what seemed to be a novel arrangement which they had been trying recently at Broomhill Colliery with the steam loop under peculiar conditions. But owing to various causes, which need not be detailed, the steam loop is not yet in working order; it was thought, however, that they had reached a stage at which the arrangement might be laid before the members of the Institution.

The ordinary application of the steam loop is now thoroughly understood; it has been put up at a good many collieries and other places, and in each instance it appeared to answer very satisfactorily. There was one at Broomhill Colliery which had been working for some months.

The object of the steam loop is to return the water of condensation; *i.e.*, the steam condensed to water in the steam pipes, to the boiler; so that instead of discharging the hot water by means of steam traps and so losing it, the water, hot and pure, came back to the boilers. The apparatus is illustrated in Plate XV.

It is evident that the steam loop will return the water of condensation when the pressure, due to the vertical height to which the water has to be raised, is less than the pressure of the steam. But it occurred to the writer that it might elevate the water to a much greater height, because as the inventor has pointed out the water of condensation passes out, not as a solid column of water, but as a column of water filled with small bubbles of steam, so that the steam has not to lift a solid column of water, but a column of water and steam bubbles.

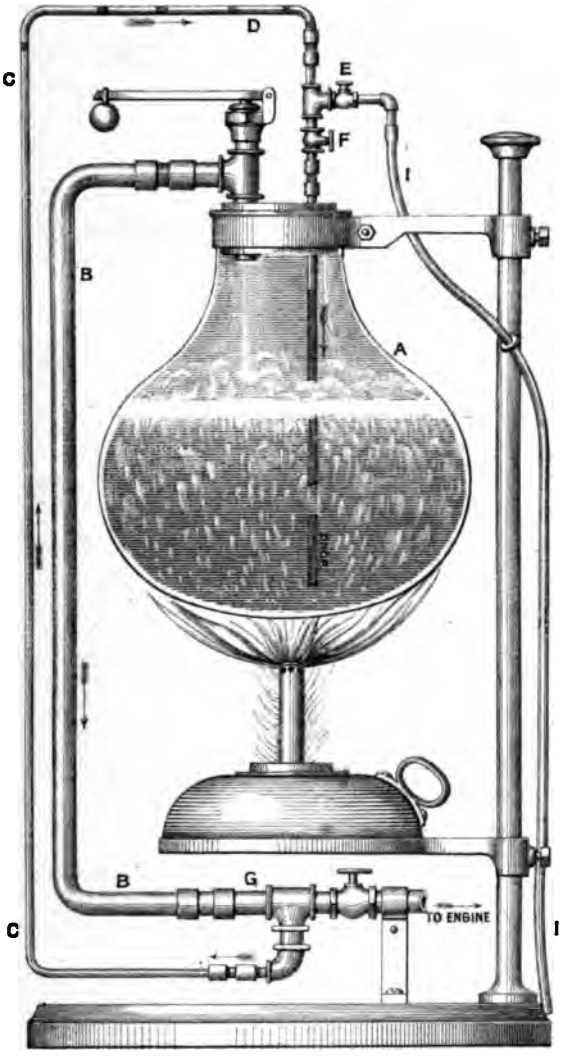
The suggestion was laid before the local agent, who agreed with the author that the steam loop might be applicable at a colliery where the steam engine was below ground and the boilers at bank. As Broomhill Colliery was only 330 feet deep, riser included, they determined to try it there, and Plate XVI. shows the arrangement of the steam loop working from the bottom of the pit.

The action of the steam loop depends upon the weight of the water in the drop-leg plus the pressure of the steam being sufficient to force the water to return into the boiler. Up to the present time the water has not been returned to the boiler, but it readily ascends to the top of the shaft, a vertical height of 330 feet. Here there is a pressure of 18 lbs., which is not sufficient to force the water into the boiler, where the pressure is 40 lbs. This loss of pressure is due, no doubt, to the fact that the steam has to travel a long distance through small pipes, and becomes practically dead when it reaches the surface; but still more to an unsatisfactory arrangement of the pipes, which it is proposed to amend. When this is done the author expects to have sufficient pressure to force the water of condensation into the boilers.

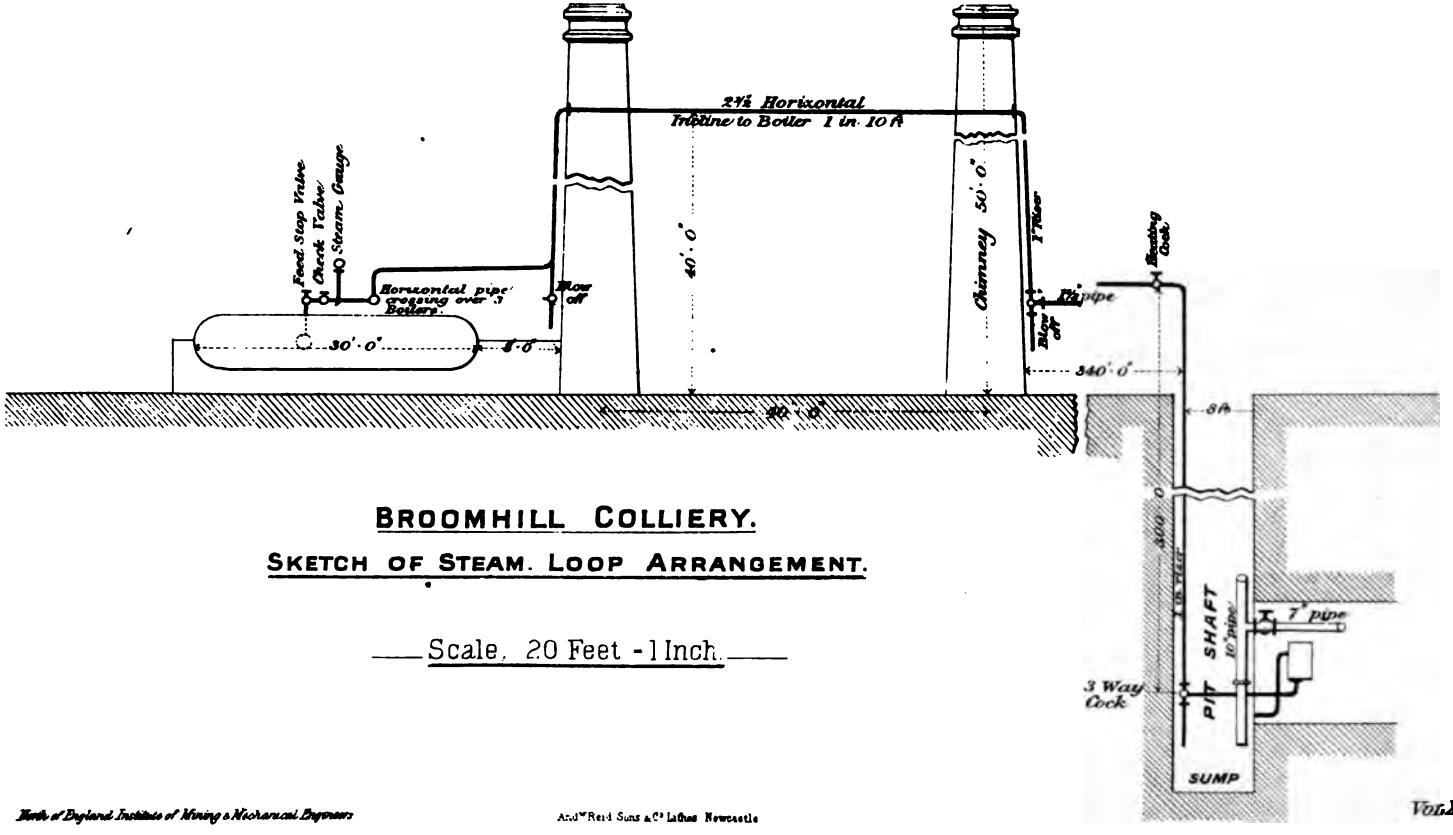
The experiments prove that by this application of the steam loop, apart from forcing the water into the boiler, there is a distinct advantage; the hot water is raised out of the pit where it is not wanted to the surface, where by the use of a pump it can be forced into the boiler. The experiments will be continued with

To illustrate Professor Merivale's paper on "The Steam Loop and Separato

VIEW OF MODEL STEAM LOOP AND SEPARATOR.



To illustrate Professor Meriwale's paper on "The Steam Loop and Separator."



BROOMHILL COLLIERY.

SKETCH OF STEAM. LOOP ARRANGEMENT.

Scale. 20 Feet - 1 Inch.

And.w Reid Sons & Co.s Lithos Newcastle

the steam loop, and it is hoped that it will become a success, and be found capable of raising the condensed water from the bottom of the shaft into the boilers at bank.

Plate XV. shows the model constructed by the inventor of the steam loop, for the purpose of illustrating its action; and is more complete than the rough model constructed and shown by the author of this paper. A is the boiler; B, the steam main; C, the return pipe and riser; D, the horizontal pipe; E, the blow-off pipe, for the purpose of clearing the system of water before starting; F, the back pressure valve, opening downwards only; and G, the position of the separator.

Mr. M. H. MILLS (Mansfield) said that Professor Merivale mentioned that the arrangement had been tried at one or two places. He would like to know where?

Professor J. H. MERIVALE said that there were two at Broomhill, one working under ordinary conditions, by which the water was elevated 30 feet; and he was informed that Mr. Blackett had one.

Mr. W. C. BLACKETT—No.

Professor MERIVALE said there was one at Redheugh, and another at Richardsons' paper mills, which were worked under ordinary conditions. There is no novelty about them; but the point he wanted to bring before the meeting was the fact that they were elevating hot water over 330 feet. He thought someone might have tried it at a greater lift than that. Apart from the payment of royalty to the patentees, there was no expense beyond the cost of the pipes.

Mr. J. A. G. ROSS (Newcastle) said he would like to ask Professor Merivale if he had any data as to the economy of the system. It seemed to him that the operation was carried on entirely by the condensation of the steam, consequently the system would be a very expensive one. Perhaps Professor Merivale could give them some information as to the increased condensation, from which some idea might be formed as to the cost of applying the steam loop, as well as the method of working it?

Mr. J. HUGHES (Dudley) said he would have asked the same question. The steam loop was very successful in dealing with condensed water; but the question was, whether it would pay or not. It was just possible that by putting in pumps one might raise the water with less expense. In commencing the operation it was necessary, he supposed, that a certain amount of steam should be consumed to form a vacuum. It would probably be necessary to open a cock somewhere near the boiler to let the steam blow through and expel the air and water standing in the pipes; when this was accomplished the cock would be closed, and by means of the vacuum the condensed water would be pushed through the pipes. The operation continues entirely by virtue of the steam condensing in the horizontal uncovered length of pipes forming part of the loop. But the question was, "Will it pay to do this?"

Mr. W. C. BLACKETT (Durham) said he would like to ask Professor Merivale whether the amount of water condensed in the pipes was kept warm whilst passing through 300 or 400 yards of pipes? otherwise it would naturally decrease in temper-

ature before reaching the boiler; and there must be a large consumption of steam to maintain the temperature of the water. Mr. Hughes very properly remarked that a pump might do exactly the same work cheaper and better. Perhaps Professor Merivale would make it more clear as to the economy of the system?

Professor ARNOLD LUPTON (Leeds) said there was, of course, no doubt that there was a great amount of power in condensed water; every unit of heat in every pound of water was equivalent to 772 foot-pounds of work, and of course to lift water up a height of 330 feet required rather more than 330 foot-pounds of work for every pound of water elevated; it might take 400 foot-pounds to lift one pound of water, but if the water was boiling, 772 × 212 represented the foot-pounds of work in the water; therefore the actual percentage of power necessary to lift the water was insignificant and trifling compared with the amount of heat in the water lifted. The question which arose was therefore as to the most economical way of lifting water. A pound of steam contained five times the heat of 1 pound of condensed water, and if it took 1 pound of steam to raise 5 pounds of water up the tube, there was no economy in lifting the water up the tube, but if it took less than 1 pound of steam there might possibly be some economy. He felt sure that Professor Merivale would be able to give them information as to how much steam was expended in returning the water to the boiler. He might remark that if the velocity of the water in the pipes was comparatively high there would not be much cooling of the water during its passage from the bottom of the shaft to the boiler, as it would have little time to cool in transit.

Professor MERIVALE said he could not offer any information at present with reference to the economy of the arrangement, and it was very possible that he never would be able to do so. It was very difficult, as they were aware, to conduct experiments so as to get accurate, and what he might call scientific results, and especially at collieries, where the boilers were all together and supplying steam to several engines. He had the practical result, for they had previously been troubled with the hot water below ground and the steam loop occurred to him as a means of getting rid of it, and if they could only get rid of the water, apart from anything else, he would be satisfied. With reference to the quantity of steam used there was this point which would enable one to form some idea: the loop pipe was 1 inch in diameter and the steam pipe was 10 inches; if both pipes had been kept fully open there would be a loss of 1 per cent. Of course the steam loop was always open whilst the steam pipe was not, but on the other hand there was the condensed water filling up the loop pipe to a certain extent, so that he thought in an arrangement of this kind they might say roughly that about 1 per cent. of the steam was used in working the steam loop. With reference to the heat of the water, all the pipes at Broomhill were covered, a 1 inch pipe was inserted inside a pipe 1¼ inches diameter; and the 1¼ inch pipe from the top of the shaft to the boilers, except in the vertical length or the drop-leg, was coated with non-conducting composition, so that the water was delivered at a high temperature. There was also the advantage of the water being pure instead of the bad water with which most of them had to deal. All these questions must be considered from a practical point of view.

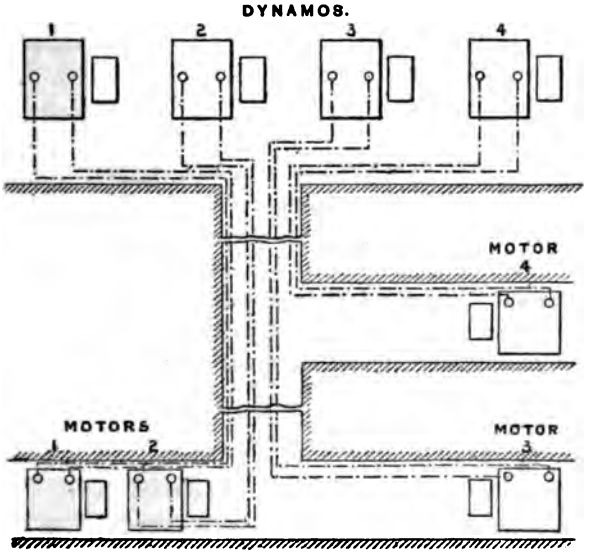
With reference to blowing steam through the steam loop pipe, of course they had to clear the pipes to begin with, but this was done once for all. They might do it on the first day of the year, and if the engines were kept running it need not be done again.

The PRESIDENT said he was glad to find that Professor Merivale was continuing experiments upon the steam loop, and that he would communicate the results to a future meeting. He had great pleasure in proposing that a vote of thanks be given to the Professor for the very lucid way in which he had explained the steam loop by means of the model he had placed before them.

Mr. J. B. SIMPSON seconded the motion, which was unanimously adopted.

DISCUSSION ON MR. ALBION T. SNELL'S PAPER ON "THE DISTRIBUTION OF ELECTRICAL ENERGY OVER EXTENDED AREAS IN MINES."

Mr. ALBION T. SNELL (London) said the discussion to-day was to be upon a paper which he had the pleasure to read to them twelve months ago at Sheffield, with a view of showing that more than one motor in a mine could be driven from one dynamo at bank. Fig. 11, page 153, Vol. I., represented what might be termed an ideal colliery as far as the electrical arrangements were concerned. The diagram represented a plant of five motors, but the greatest number he had hitherto arranged on one system was, he believed, four. At St. John's Colliery, near Normanton, they had six or seven machines at work, but these were on a different system; thus:—



In the engine house were two large engines, and the dynamos were arranged to work the corresponding motors (dynamo 1 to motor 1, dynamo 2 to motor 2, and so

on), but the whole system was interchangeable, and the dynamos could be connected with any motor at will. These remarks were only intended as introductory, and if the members would criticise the paper he would endeavour to reply.

Mr. SYDNEY F. WALKER sent the following communication, which was read by the Secretary:—

Firstly, as to the voltage that should be used, I observe that, while Mr. Snell states that at the time his paper was written he had not used a higher voltage than 725 volts (though he had designed a pair of motors for use with 1,000 volts), he states rather regretfully that he fears that not more than 500 volts will be used as a regular thing. He is evidently in favour of higher voltages. I would, on the contrary, most strongly advise mining engineers who think of adopting electricity as a means of transmitting power not to use higher voltages than they can help. If possible, the voltage used should not exceed 100 or 110 volts—that used for the ordinary incandescent lamp service—until the ordinary workmen are more familiar with electricity, and for the following reasons:—

(*a*) It will simplify the working of the electrical plant at a colliery if the lights and motors can be supplied from one source, the motors being reckoned, as I will show later, merely as so many lamps according to the load on them. I am aware, of course, that it is possible to run 100 volt lamps from, say, a 500 volt service, but it is only by calling in the aid of the complicated parallel series system of connections that are sure to give trouble in mines, and which necessitates a number of lamps being fixed where perhaps only one may be required.

(*b*) On account of the difficulty of maintaining the insulation of cables and other apparatus in mines as the voltage is increased. High tension dynamos in use at the present time (those furnishing 1,000 volts and upwards) never are properly insulated under any circumstances, though they are sufficiently so for ordinary work on the surface. The result of this defective insulation, which is approximately in proportion to the voltage used, is that a small current is always passing through the insulating material itself and gradually altering its nature by the process known as electrolysis, thereby decreasing the actual insulation, whatever it may be, with which the system started. This is particularly the case in a mine where the cables, the lamp, and switch fittings, and the motors, are subject to so many things that they would not meet with on the surface; and where the rails, the ropes, even the mass of the coal or metallic ore, of which the mine itself is composed, take part in the action, as when once the insulation of either dynamo, generator, or motor, or of any other part of the apparatus is defective, the whole of the mine becomes a path for the leakage current.

(*c*) My third and gravest reason for recommending so strongly that only low voltages should be used in mines is the great danger of shock to those using the apparatus, or who may occasionally be brought into contact with it. It should be remembered that, though the shock from a current at a pressure of 300 volts or even 500 volts is rarely dangerous *per se*; that is to say, if a man receives a shock of even 500 volts and nothing else, it is not often that he receives injury; yet coming

as it may do quite unexpectedly, it may throw him into a position, say in front of a journey of trams, whereby he will receive very severe injuries. I know that in the ordinary course of my business I have often been standing in a mine waiting for a journey to go by, where I should have been very sorry to have received a sudden, sharp shock.

In addition to this, also, should the circuit be broken, or the strength of the current passing in the circuit be varied largely at the moment when contact is made by a man working in the mine, with some part of the apparatus, he may receive a momentary shock many times greater than the normal voltage of the system, owing to what Faraday called the extra current, the E.M.F. induced within the coils of the dynamo itself, which is added to and multiplies the normal voltage of the dynamo. So that, it is quite possible, with a normal voltage of only 500 volts to receive the momentary shock of 2,000 volts, which is sufficient to cause instant death.

Secondly, I note that Mr. Snell rather hesitatingly allows the use of a naked return in certain cases. His only reason for condemning it would be the possibility of motors not working well under certain conditions if a naked return is used.

I would most unhesitatingly condemn the use of the naked return under any circumstances, and for the reason already hinted, that it enormously increases the possibility of shock, and the difficulties attendant upon the preservation of the insulation of the system.

If a naked return is used, the whole mine becomes at once a portion of the return circuit, and any trifling fault that would not become serious for a long time if the whole system were insulated, becomes at once serious, as the other side of the circuit is met with everywhere.

The troubles that have been described in dealing with the matter of voltage are all increased considerably, and for the same reason. The leakage current finds a very much easier path than even with imperfect insulation. And lastly, but by no means least, the dangers to users are also enormously increased. With two cables perfectly insulated, a man must place two portions of his body, say his two hands, in contact one with each cable, or something connected with it. Where a naked return is used he is already in connection with one side of the system wherever he may stand in the mine, except, perhaps, on the hard dry wood floor of an engine house, if such a thing exists. He has then only to touch a bare place in the cable, a bare terminal of a motor, switch, or other apparatus, and a current will immediately pass through him to the other side of the system by way of his feet and his boots. The violence of shock he gets will depend upon the voltage of the system, and the state of his hands, his feet, and his boots at the time. If these are all wet he may get a severe shock from even 200 or 300 volts, and even from a lower voltage than these, if the circuit be broken or its current changed at the same time. It is partly from this cause that so many deaths have occurred in the United States and elsewhere from men incautiously touching arc lamps.

I am aware that the alternative to the use of naked returns and comparatively

high voltages is the use of larger and more expensive cables, meaning, possibly, slower progress in the development of the electrical power industry. But I believe that it will be far better for us to move slowly than to have the set back that would be caused by a death in a mine from shock. I am also aware that it will not be an everyday occurrence for a man to place himself in the dangerous positions indicated; but it is also well to remember that such an occurrence may take place any day, and should therefore be provided against as far as possible. As workmen become more familiar with the properties of electric currents it will be quite safe to use higher and higher voltages, just as the intense heats of the blast furnace and the Bessemer are easily dealt with by men accustomed to them, where they would be highly dangerous to those not so accustomed. It should also be mentioned that the use of a naked return very much increases the danger and possibility of sparks, a cable may rub its insulation through on the edge of a metal plate or bracket, and sparks would be very liable to pass between the two, as the metal would almost certainly be connected directly or indirectly to the return. I should also mention that the above is taken very largely from actual observation, and from reports that have been made to me of what has actually taken place in mines; the argument merely being filled in by reducing the phenomena involved in these cases to the principles of electrical engineering.

Thirdly, I would also strongly condemn the use of old wire ropes in mines, either for main or return, and this in spite of the success that has, I understand, so far attended the work of Mr. Sopwith and others in this direction. All that has been said above is true of the use of old wire ropes, but in a very much more dangerous form. If insulation is difficult with a naked return, it is almost impossible with two naked mains, and therefore the use of tensions such as 300 and 500 volts, which may be comparatively safe while the installation is new and the insulation very high, would be positively dangerous under any circumstances where two naked mains are used. Further, with 80 and 100 volts, which are the voltages, I understand that Mr. Sopwith uses, and far more with higher voltages, there is very great danger of sparks. It is quite easy to place the two ropes out of sparking distance of each other, but it is almost, if not quite, impossible to prevent each of them from making connection with other masses of metal, which in turn may make contact with yet other metals, and so two adjacent pieces of metal far removed from either dynamo or mains may be in connection with the opposite poles, plus and minus, of the system, and give rise to sparks when some vibration causes them to separate for a moment. I have seen this actually take place in a mine in South Wales, very much to my own surprise, though I had ventured to prophesy some little time previously that there was a danger of such a thing happening, and I had been sent for in triumph to see that my prophecies—this and some others which also came true—were only old woman's croakings.

I would also point out that the conditions present in Mr. Sopwith's case can rarely be present in others. I understand that when Mr. Sopwith determined to adopt electric light, he first studied all that was written on the subject, and as far

as was possible, mastered his subject before going into it. I believe that a paper I wrote on electric lighting for the North of England Institute had the honour of being well thumbed. Further, once started in this way, his whole staff taking the same interest in the matter as himself, failures were only experience which led to success.

I believe I am right in saying, however, that few colliery managers have time to follow in Mr. Sopwith's footsteps; and meanwhile Providence appears to have been very kind to him in dealing with his electrical apparatus very gently.

I should also like to point out that in Fig. 4, page 145, Vol. I., showing the characteristic curve of the series dynamo, Mr. Snell has left out the most important part of the curve. As shown it would appear that, with constant speed, the E.M.F. rises with the current to a maximum, and then stops. This is not so, though in showing the curve in this form, Mr. Snell sins with the majority of the text books. The curve bends over after a certain current is reached, and the E.M.F. then becomes less and less with every increment of current. The reason is, that with constant speed, the E.M.F. is proportional to the strength of the magnetic field in which the armature of the dynamo revolves; and this is proportional to the current strength in the wire coils on the field magnets as long as the iron of which they are composed is only lightly magnetized. As the magnetism increases, the magnetic resistance increases till the increased current does not bring sufficient increased E.M.F. to pay its own toll for passing through the wire of the field-magnet coils; and then the E.M.F. declines. This feature has been found of great importance in the construction of dynamos for arc lighting, and will also prove to be so in that of motors. I would moreover draw attention to the fact that Mr. Snell alludes to a varying E.M.F. at the motor terminals, with a constant E.M.F. supply, owing to varying current, of course from varying load. I do not think that this need be so, or should be allowed to be so. We do not permit a variation in the E.M.F. at the terminals of electric lamps that will cause a noticeable variation in the light, and we arrange this by finding out what variation in the lamp is allowable, and calculating the size of the mains to allow of only this variation of E.M.F. under the regular conditions of use in the mine or wherever it may be. My view is that the same thing should be done with supply cables for motor purposes; and further, that the regulation should be done entirely within the motor for its own work, and not by means of variable resistances or by varying the speed of the engine as is now often done.

Whether a motor runs light or with a heavy or medium load, means merely with constant E.M.F. supply, that it absorbs more or less current, and any variation in its load is equivalent under those conditions to variation in the number of lights burning.

If the E.M.F. at the terminals of the motor is also allowed to vary, as it will do if the cables are not large enough to maintain it constant, other and troublesome complications come in. In my view, there should be one voltage for all the work, and the supply at any part of the mine should be at as constant an E.M.F. as possible. With this arrangement the whole thing becomes simplicity itself. I

would also recommend the use of a compound-wound dynamo as generator and either series or compound-wound motors, the whole run on what is known as the simple-parallel system.

I trust that in the above remarks I may not be taken to disparage any of the work Mr. Snell has done. So far as I have seen his work has been remarkably good, and he has done good service to the cause. I have merely endeavoured to point out dangers which are perhaps more apparent to me, from my longer acquaintance with mining work.

Mr. A. L. STEAVENSON (Durham) said the paper did great credit to the writer, who was evidently a man of science and who had had much experience in electricity, but it was doubtful whether he had had much experience in mining, and those who had had experience in mining had probably not had much experience in electricity, and each were ignorant of the necessities of the other. If the mining engineer was not aware of the dangers which occurred through electricity, and the electrician was not able to realise the immense danger that might accrue through setting the shaft or mine on fire, they might both from ignorance commit great mistakes. Thirty-six years ago he happened to hear that a colliery shaft was on fire; he found that they had only one pit, and some seventy men were below. The night was spent in trying to get the fire out, and they succeeded so far that by morning they were able to blow the remains of the fire out by throwing a cask of gunpowder down the pit; but he was so impressed with the dangers of fire on that occasion that he would never forget it. They all knew that if a fire broke out on a wagon-way, or other place, where there was a large supply of air, it was practically impossible to rescue the men who might be on the in-bye side of it. These were the risks attending the use of electricity in mines, for no doubt that as soon as electricity escapes it becomes fire. Nobody knew exactly what electricity was, but it was probably some form of motion, the same as heat, and that instead of carrying ropes and wires about, as they supposed, they were in reality carrying fire about the mine. They might consider he was an old fogey, who was not inclined to try anything new, but a fire, whether from electricity or not, was a very serious matter for all concerned. In the case of the shaft on the diagram (Fig. 11, page 153, Vol. I.), what better means could be adopted for drawing water from the bottom than the ordinary quadrant and spears, which gave from 70 to 75 per cent. of useful effect. That was a result beyond dispute, and would be proved by application to any of the water-works people, or anybody who had had any experience in the matter. Mr. Snell stated that he got 45 per cent.; he therefore lost 30 per cent., in addition to the risk of setting fire to the pit. The preliminary part of the paper was entirely electrical, and they who were mining engineers were not able to dispute it; no doubt it was very ably written, and was a valuable paper on the subject. The writer said he had not used more than 725 volts; he (Mr. Steavenson) thought he could show that that was a dangerous pressure at which to use electricity, not only dangerous to human life, but dangerous as increasing the risk of fire. He had with him a little note-book in which he kept a few memoranda on the subject of electricity, the following were a few recent extracts:—

For instance, in a lecture recently before the Society of Arts, by Messrs. Lawrence and Harries, it is said with reference to contact, the resistance offered by the body, depends upon the extent of the contact area, and the condition of the skin at the sites of contact, varying from 1,510 ohms wet to 6,185 dry, showing that when both circumstances happen to be unfavourable "the subject may receive serious, if not fatal, injury from a circuit which might be safely handled under conditions more favourable to himself,"—and the authors go on to note "with regret that there is a tendency among electrical engineers to draw unfair inferences from the slight results which have sometimes followed accidental contact."

In the *Colliery Guardian*, in an article on "Dangers of Electricity in Mines," Feb. 27th, 1890, we read :—"If the normal tension be high the shock received on breaking circuit may and often has caused instant death; probably owing to the sudden very violent contraction of some vital organ. And, if, in addition to this, the current is not extinguished on breaking circuit, the result of such a shock, from even such moderate normal voltages as 300 volts and 500 volts, may have the same effect as the shock from a 2,000 volt current in the ordinary way. It is for this reason that the writer strongly recommends that the voltage used for transmitting power in mines for pumping, hauling, etc., should be kept as low as possible until those about the mine are more conversant with the properties of the electric current. Instead of the 500 volts and 300 volts at present in use, in most cases he would recommend that 100 or 110 volts, the electro-motive force generally used on incandescent lamp circuits, should be adopted. It should be remembered that in a mine, even if the shock a man receives does not injure him, it may, coming unexpectedly as it usually does, throw him into a position among moving ropes or machinery, where he may receive a severe injury."

With respect to fires, one or two extracts out of many will suffice, all showing, of course, that if everything goes right no harm is done, but if anything goes wrong (and we know fire in a mine is not a question to be left to chance) then the case is serious indeed. Thus, Mr. Preece, F.R.S., addressing the Society of Telegraph Engineers and Electricians (see *Engineering*, May 13th, 1888) says :—"At Derby a fire was caused by a short circuit arising between the leads to a lamp and a tin shade behind it."

"On Sunday night, in the Comedia Theatre, Madrid, an alarm of fire was raised. There was immediately complete darkness in the theatre, and the consequences of the panic might have been serious but for the presence of mind of some of the audience. The theatre is lighted by electricity, and through the contact of imperfectly covered wires the canvas in the side scenes had caught fire. In Spain, as in England, the lesson is not yet well learned that the care which is necessary to prevent fire from the use of gas cannot be dispensed with in the case of electricity."—*Iron and Coal Trades Review*, December 28th, 1890.

"A spark will pass also if a conductor in which a current is passing be severed, say a cable parted by roof falling on it, or a wire cut by a knife or other sharp instrument. Another point where sparks pass is at the commutator of the dynamo, or motor. The armature of the dynamo is composed of a number of coils of wire which

are connected to the copper segments of the commutator, and that which is true of electric lighting applies equally to transmission of power."—*Iron and Coal Trades Review*, March 27th, 1890.

Rats and mice were a source of great danger, as was the practice of burying insulated wires in cement during the building of a house. Another great danger was overloading the main. Bad joints were, however, the greatest danger, and soldered joints generally considered essential; joints depending on screws should be avoided. In one installation, he knew, there were 6,000 joints of this character, each of which might sooner or later be a source of grave danger of "cut-outs." He said that it was well known those were dangerous if not properly looked after, as was also the case with switches.

With regard to the insulating material, what was wanted was an insulating medium that was non-inflammable, but very few, if any, now in use were of this character.

Mr. J. W. Swan said when he first showed his incandescent lamp, Mr. Preece raised the question of risk of fire; he then thought Mr. Preece was pitching his note in too high a key, but he had since altered his opinion, serious mistakes being made by even good electricians.

Many cases of fires from electric wires could be cited if necessary, it has been said that similar risks occur from candles, but that is not so; when a fire begins from a naked light, someone is always there to extinguish it; but we have miles of electric wires, and no one near to see a fire until it is too late.

He did not suppose anybody would be foolish enough to take electricity into any place where there was a possibility of an explosion, but his remarks were now in reference to places free from gas, such as wagonways, shafts, etc. Reference was made in the paper to the great distance to which electrical power could be carried, but usually they did not require it carried to any great distance; about 2,000 yards was all they required, and when the distance was as great as 5,000 or 6,000 yards it did not come within their scope. In conclusion, he wanted particularly to impress upon the members that there was really no great gain, if any, by using electricity. If there was not room in the shaft for a pump he would advise the use of hydraulic power. On the top he would have a pressure of 500 to 700 lbs. upon the square inch. If he had to pump a long way in-bye he would take the alternative of compressed air or ropes. His impression was that although in some cases electricity was desirable, these cases were very few and far between, and the risk of setting the pit on fire with the electrical wires was a very serious one to run.

Mr. M. H. MILLS said the remarks of Mr. Steavenson were very valuable, especially to young members who were inclined to go ahead; electricity seemed to be a matter which required a great deal of study, and there was every reason why it should be added to the studies of the mining engineer; the great danger seemed to be in having the positive and negative wires together. Why not have them separate? Why not take the positive wire down one pit and the negative down the other? Mr. Steavenson seemed to think that there were not many cases where electricity was of

real value, but there were; in some of their large collieries where ropes were used it was not always advisable or convenient to be continually running them if there was only a little water. There was no doubt electricity would be more generally used in the future. He would like to ask if there was any difficulty about sparks escaping at the motor?

Mr. E. BROWN (Normanton) said the dangers were more apparent than real. At the St. John's Collieries they had had three years' experience with the dynamos and motors at 700 volts; they had not got off without slight shocks, which were rather unpleasant, but they had done no harm. The few shocks he had received himself were when they first started the use of electricity and when they were ignorant about it. It would be a step backwards now to put down a plant at less than 700 volts. Nobody thought because a steam pipe happened to burst at 50 lbs. per square inch that they should go back to 30! The voltage would probably be higher as they got to know more about the subject. At St. John's Collieries they commenced with electricity at a much lower E.M.F., but they soon increased it to 700 volts and he thought they would continue at that. He quite agreed with Mr. Snell's system of transformers for small motors, but where it was possible to run up to 30 horse-power, they should keep to 700 volts. There was not so much danger and trouble as was generally supposed, but it generally arose through people not giving sufficient thought to the matter; they were not accustomed to it; but after having had a motor of 700 volts a few months they would be able to manage it as well as they now did at St. John's Collieries after three years' experience. Compressed air was not, in his opinion, to be compared with electricity. A pair of 20½ inch engines did twice as much work with electricity as three did before with compressed air. If they had continued with compressed air they would have had to put down more compressors and this would have meant more boilers.

Mr. STEAVENSON said he understood the last speaker to say that compressed air was superseded at St. John's by electricity. Well, he had seen the plant at that colliery, which had been very imperfect. Was not the compressed air worked direct from the engine?

Mr. BROWN—Yes.

Mr. STEAVENSON—And the engines that would not do the work with compressed air did it with electricity, because when you took away the compressed air you increased the revolutions and therefore the engines did more work.

Mr. BROWN—I indicated the engines when they were compressing air; they formerly ran up to fifty revolutions per minute—they still run at fifty, but indicate less horse-power, although doing more work in the pit; we simply put the shafting on to increase the speed for driving the dynamos. This increased duty is easily explained, as we are now getting an efficiency of 50 per cent. by our electric transmission; but with compressed air I think in ordinary work 25 per cent. is not exceeded.

Mr. STEAVENSON.—If you had cooled the air during compression by a proper injection of water, the same engine would have done the work as well as by the dynamos.

Professor ARNOLD LUPTON agreed with a good deal of what Mr. Steavenson

had said, and also with a good deal of what Mr. Brown had said, and he would like to venture one or two criticisms on the paper. Firstly: The writer said he would have a comparatively high tension—not what electricians would call high tension, nothing like 10,000 volts, but a comparatively high tension—coming down the shaft to a transformer in the workings, and then he would take low tension electricity from this transformer to the machines farther in-bye. How far would Mr. Snell fix the transformer from the dynamo? On looking at the diagram (Fig. 11, page 153, Vol. I.) it did not appear to be a very great distance. The diagram shows a shaft of, say, 300 yards in depth, and one of the motors perhaps 500 yards from the dynamo, the other 1,300 yards farther away. Was it proposed to have the 1,300 yards on the low tension, and the 500 yards on the high tension, or *vice-versâ?* If it was proposed to have it thus, was it worth while having a transformer? Could not the mains be thickened for the first 500 yards and be continued on the low tension all the way? Mr. Snell would perhaps make that plain in his reply. At present he (Mr. Lupton) understood the paper to propose to introduce high tension in the shaft in order to economise in the thickness of the main lead, and he inferred that this economy was between the dynamo and the transformer. If the transformers were tolerably near the shaft bottom the length of high tension wire was only short; if the transformer was a long way in-bye, then the difficulties of high tension were existing over a great part of the mine. Secondly: Mr. Snell claimed superiority for electricity over other means of transmission. If there was the transformer, what became of the economy of transmission, supposing it to have existed before? He understood the transformer to be—as was the rule with all continuous current transformers—a motor driven by the original dynamo, which motor drives another dynamo, which dynamo gives off the low tension current; thus the transformer constitutes itself a motor and a dynamo introduced between the original dynamo and the motor, working a pump, or coal-getter, whatever it might be. Now, how much of the power would that motor and dynamo absorb? The speaker would fix it at 20 per cent. in his own mind. Mr. Snell had written a useful and interesting paper, in which he said that the loss of horse-power in transmitting the power to the dynamo axis in electrical measurement varied from 15 to 6 per cent.; that is, 85 to 94 per cent. was realised, and it was to be gathered—though it was not so clearly stated—that the loss in transforming electrical energy into mechanical force was much the same, so that in each transformer (which was motor and dynamo together) there would be a loss of from 12 as a minimum to 30 as a maximum, which might be averaged at 20 per cent. Thus there was 20 per cent. loss introduced into the system for the sake of making it applicable to the small motors in the one case and to the high tension in the other case. With regard to the cost of the transformer, Mr. Snell mentioned £8 per horse-power. What kind of a transformer was it that would cost only £8 per horse-power? Was it a shunt wound, compound wound, or series wound transformer? He thought the motor would be series wound. Would the dynamo—the transformer dynamo—be compound wound, the same as the original dynamo in the

engine house? If so, could that be supplied at a cost of £8 per horse-power? It was not mentioned in the paper what tension of electricity Mr. Snell would recommend for the original dynamo; 750 was mentioned as the highest Mr. Snell had used. The use of transformers was afterwards dealt with at a pressure of 500 volts. Another point affected the economy of electrical haulage. Supposing they were hauling up an incline and wished to vary the speed of the motor, how could that be done? He (Mr. Lupton) had given some little attention to these questions, and had made enquiries from practical electricians, and the answer he had received was this: If you wish to vary the speed of your motor you must introduce resistance, and if you introduce resistance an appreciable percentage of the power is absorbed. For instance, supposing the motor and gearing and drum is fixed to work at a speed which we will call 100, and you wish to reduce it from 100 to 80, you will have to put in resistance which will absorb 20 per cent. of the power, and if you want to reduce the speed from 100 to 50 you will have to put in resistance which will absorb 50 per cent. of the power. Mr. Snell would perhaps answer this point in his reply; it seemed to bear very much on the question of economy. Mr. Snell, on page 150, says: "Some care is required in starting motors of these types." What does that allude to? With regard to the economy of electricity as compared with other modes of transmission of power, he (Mr. Lupton) had examined the machinery at St. John's Collieries, and had indicated the engine—not the latest engine in use, but another one which was driving a pumping engine in the pit, and which was described by Mr. Snell in his paper now under discussion, and the statements there made as to the useful effect of the dynamo in pumping water were fully sustained by his own observations, although those observations were not made with that minute accuracy that they might have been if there had been more time, yet they were confirmed by statements and figures more carefully made by Mr. Brown. These figures showed that of the total engine power—the pump being at a distance of 500 yards from the engine—43 per cent. was returned in the shape of water lifted. Now, a pump of fairly good construction driven by steam would give about 80 per cent. of the steam power in water lifted; this was to be taken into account in arriving at what he would call the indicated dynamo power in the pit. Supposing an indicated horse-power of 100 in the dynamo house, what indicated power would there be in the electric motor in the mine? His observations gave the useful effect as 54 per cent., in this instance, at a distance of 500 yards. It did not follow that because they only got 20 per cent. of useful effect at St. John's Collieries with compressed air that that was the maximum that could be got by any compressed-air system. Supposing, for the sake of argument, the compressors were as good as they might be, it did not follow that the motors were first-class; the valves might not have fitted properly; and until they had particulars of all this it did not prove whether the fault was in the system or in the particular example. He required a good deal of convincing yet that electricity was more economical in mines than compressed air. He had perhaps troubled the meeting at some length. As an excuse, he might say that although he had been a member of

the North of England Institute for twenty years he had never before spoken in Newcastle at any meeting of that Institute.

The PRESIDENT would like to ask Mr. Brown, was there not at one time a cable injured by a cage falling against it?

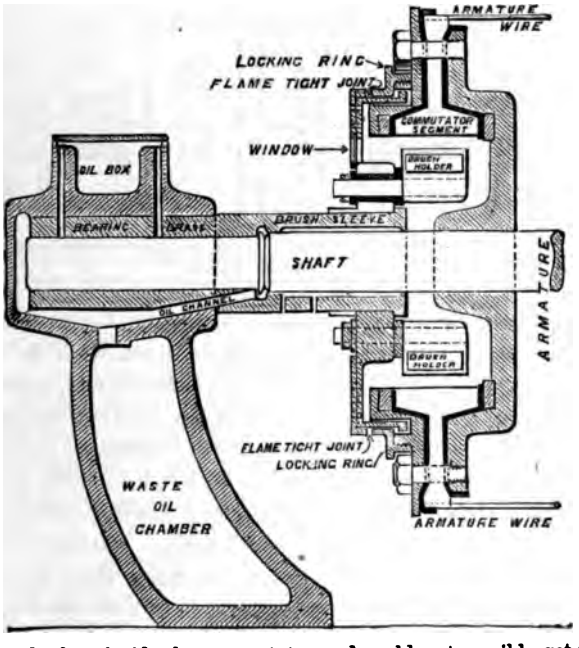
Mr. E. BROWN—Yes, sir.

The PRESIDENT—Did any injury result?

Mr. BROWN—The two cables were fused through short circuiting; that was all.

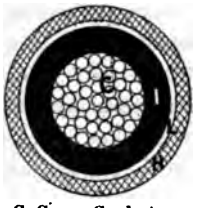
Mr. SNELL, in replying, said, that the discussion, had been very interesting, for they had heard the opinions of practical men on both sides; he only wished they had heard more on the side of compressed air. It was difficult to reply to all the points raised, but he would endeavour to take them in order. In Mr. S. F. Walker's communication, there was a wish to limit the pressure to 100 volts. Mr. Walker could scarcely have thought the matter out or he would have seen that it was impossible to work at that tension. Let it be compared with the pressure he was advocating. With 100 volts they would require five times as much copper as with 500. Now, copper was a very costly commodity, and with five times as much copper it would be impossible to adopt electricity. He (Mr. Snell) ventured to assert that a tension of 500 volts with direct current was not dangerous to life under ordinary conditions. Mr. Brown had tried 700 volts for three years, during which time every possible contingency had probably happened; a number of men had received shocks, but nobody had been burned or injured. He did not say that under certain conditions 700 or even 500 volts was not dangerous. Another point raised by Mr. Walker, was that of naked returns. On this point again experience should be brought forward. He must not be understood to advocate naked returns in a large system, but where they had only one machine he did not see any great objection to it. At Andrew's House Collieries there were three small motors working in-bye, and the returns were old wire ropes, the tension was about 300 volts; this plant had been running over twelve months and one or two men had received shocks, but they certainly had not been hurt. He would not put in naked returns in a large system; in one such as that shown in (Fig. 11, page 153, Vol. I.) they ought to be insulated in the best possible manner. Mr. Walker also made reference to (Fig. 4, page 145, Vol. I.) and accused him (Mr. Snell) of an error in the curve, but he was in good company, for he erred with the text books written by men who were able to speak with authority. Fig. 4 was, however, correct; it was the working part of the characteristic curve of the machine. If the machine was overloaded the curve would become flat, and parallel to the line of abscissæ, and then droop, until a point was reached where the dynamo would tend to burn up through the volume of current being too great. The same objection might be raised in regard to all the curves; the length of curve shown in Fig. 4 corresponded to the working range of the machine. There were one or two other points raised, such as the variation of the E.M.F., but Mr. Walker's meaning was not quite clear; at all events it was not necessary to go into this now. Mr. Steavenson made some rather sharp remarks on the danger of using electricity. His note-book seemed to be a large one, and contained, no doubt, much valuable information

from various sources. He would be inclined to agree with Mr. Steavenson that 200 volts with alternating currents was a sufficiently high tension, but he was not advising the use of such a current. He would say generally, that it was not advisable to take an isolated experience in matters of this kind, but the general experience. Electricity was being used for many purposes throughout the world, and he did not think they had ever heard of a case where death had resulted from a tension so low as 500 volts. All the cases that they knew of—unless there were some peculiar circumstances in connection with them—were the results of tensions of 1,000, 1,500 and 2,000 volts. Mr. Steavenson demurred as to the advantage to be gained by using electricity, and took rather an unfair illustration, as he assumed from Fig. 11 (page 153, Vol. I.), that he (Mr. Snell) proposed to work mine pumps in all cases by electricity; this was not so, and the diagram was applicable to a special case, in which the prime source of power was not steam, but water. The main advantage of electricity is that the power could be easily and readily carried a long distance in-bye, and it was really in pumping from the dip that the great advantage was found. He mentioned Andrew's House—to put a case in point—a 2 horse-power pump was put in to work through the 24 hours, and did the same work as 12 horses. A gentleman raised the question of sparks at the commutators, and asked whether they were dangerous? Under certain circumstances they were dangerous, but great strides had been made in the direction of lessening this danger. Messrs. Davis and Stokes, of Derby, had recently taken out a patent which advanced the subject very much, the brush being placed inside the commutator, thus:—



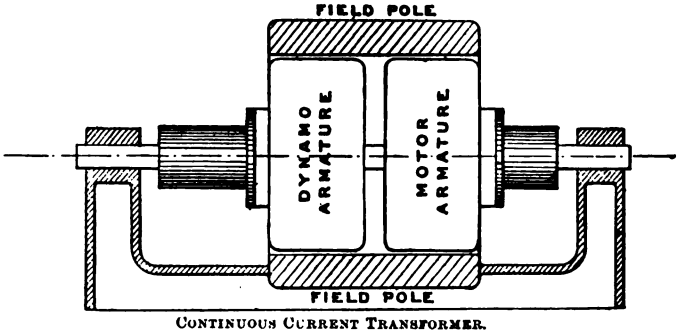
The sparks took place inside the commutator and could not possibly get through to explode the outside air. Mr. Steavenson also mentioned the question of risk from wires, and drew a very formidable picture; but again experience might be quoted.

Hundreds of miles of cable were in use, and the accidents were very few indeed. At St. John's Colliery they had had two or three little accidents, but these had not set the shaft on fire, nor entailed serious trouble or expense. If they considered the normal condition of things they would see there was not much risk, as the cables were formed of copper wire running through lead covering, thus :—



C, Copper Conductor; I, Insulation; L, Lead Covering; and H, Ozokerited Hemp Braiding.

If an accident happened, and the copper became uncovered, the current was short-circuited, and the work of the engine increased, so that the man in charge was made aware of it at once; if he did not stop the engine the fuse would be burnt out. Electricians were fully aware of all the dangers which might be occasioned by the various means indicated, and were adopting such arrangements as would, as far as possible, minimise the danger. He now came to the remarks of Professor Lupton. That gentleman raised some question as to the meaning of a transformer, but had evidently misunderstood the remarks on that point. What a transformer was intended to do was this: If there was a high tension on the mains—say 500 volts—it would be impossible to put small machines in, for the simple reason that they would cost too much. To obviate this difficulty, he proposed, in cases where they could use one or two motors together to put in a transformer—the latter being a combined motor and dynamo.



CONTINUOUS CURRENT TRANSFORMER.

The motor would be driven by 500 volts, and the dynamo would give a corresponding amount of power, less 8 to 20 per cent., with a tension of something like 200 volts or what was required. The distance was immaterial; if, for instance, at the bottom of the pit, it was desired to use some small rock drills of about 2 to 3 horse-power each, they would be costly things to work; but if a small transformer was put in they could get two or three electrical rock drills to work with a tension of 200 or 300 volts. Undoubtedly, there would be power lost, but it would be more than counterbalanced by the saving in using electrical rock drills. Efficiency of conversion was secondary to the convenience of getting the power where it was wanted. Professor Lupton also asked how it was proposed to vary the speed of the motor, when running in constant potential circuit, such as was presumed in Fig. 10 (page 151, Vol. I.)? There were really two ways of doing it: one by shifting the brush, as adopted at St. John's Collieries, and the other by putting in resistance. If the motor

was required to run quicker, turn the brush frame backwards; if slower, turn it forwards. These changes would involve a small loss of energy. If they considered a steam engine designed to yield 100 horse-power its efficiency would be less when indicating 50 horse-power; the economy would be less than at full load. It was the same with air and with electricity. The starting of compound motors was also referred to. In the compound motor Fig. 3 (page 143, Vol. I.), as ordinarily understood, there were two coils, one a series and the other a shunt-winding. He did not recommend compound-wound motors; he nearly always used plain series-winding. Professor Lupton also referred to the economy of compressed-air plants; but he (Mr. Snell) would like to refer the meeting to Professor Kennedy's recent experiments with the Popp system in Paris. He found that unless air was heated before entering the cylinder, the efficiency was not more than 22 per cent.—the ratio between the horse-power of the air engine and the indicated horse-power of the steam engine was 22 per cent. He thanked the members for the kind manner in which they had discussed his paper. He hoped it would lead to practical results. He thought—and his opinion was backed by many eminent men of the present day—that electricity was the power of the future.

The PRESIDENT said they must all feel very much obliged, not only to those gentlemen who had taken part in the discussion, but to Mr. Snell for the very lucid manner in which he had explained the subject. He (the President) agreed with Mr. A. L. Steavenson that if a fire took place in a mine the circumstances would be most serious. Did not the coal often take fire from other causes? He knew several instances from candles alone, so that Mr. Steavenson's argument might equally be applied to candles. They had had a long discussion, and he hoped at some future period it would be continued, for there were many points in connection with electricity that required very distinct elucidation. He hoped that after this discussion was printed there would be no further delay in publishing the Transactions, and that when the members had read it they would come forward and either offer a paper on electricity themselves or discuss somebody else's paper. He thought it very useful that it was not against the rule for a member to raise at one Institute a discussion upon a paper read at another. They had had some difficulty about this in connection with the Midland Institute, and he had asked the Council of the Federated Institution whether it was proper that these discussions should take place in the way he had mentioned, and was informed that it was perfectly proper, so that now they were at liberty in Yorkshire, Staffordshire, or Nottingham to pull to pieces what the wise people read in Newcastle, with the disadvantage that there would be no personal reply. If the criticisms happened to "touch the raw" of the author he could reply by correspondence, as was done in the Institution of Civil Engineers; thus they would have not an *ejective* but an *objective* correspondence, for the author of a paper would not feel very easy if he found in one of their publications a remark that he was totally mistaken in his views respecting something; so one could imagine him saying, "I will correspond with that Institute and give them my mind upon it." With these few remarks he would propose that the thanks of the meeting be given,

in the first place, to those who had taken part in the discussion, and also to Mr. Snell who had been the originator of the discussion; and they would all agree that they were well worthy of the thanks of the meeting.

The vote of thanks was heartily adopted.

Mr. J. B. SIMPSON reminded the members that at eight o'clock in the evening the Principal and Professors of the Durham College of Science would give a conversazione at the College. He begged to propose that a vote of thanks be accorded to them for their kindness. It was not usual to return thanks before accepting a gift, but they might not have an early opportunity of acknowledging their indebtedness to the Principal and Professors of the College.

Mr. JOSEPH MITCHELL (Barnsley) seconded the proposal, and it was unanimously approved.

The SECRETARY having announced the arrangements for the following day,

A vote of thanks to the President, proposed by Mr. MILLS, terminated the business of the General Meeting.

DINNER IN THE NEW ASSEMBLY ROOMS.

MR. J. B. SIMPSON, PRESIDING.

After the loyal toasts, the CHAIRMAN proposed the "Federated Institution of Mining Engineers." He was extremely sorry that Mr. W. Cochrane, the President of the North of England Institute of Mining and Mechanical Engineers, was abroad, as that gentleman ought to have taken the chair on this occasion. In Mr. Cochrane's absence the position had been allotted to him, and he only regretted that the toast had not been left to abler hands. As some of the gentlemen present might not be conversant with the details of the work of the Federated Institution of Mining Engineers, he might observe that at present it was a combination of the following Institutes:—The North of England Institute of Mining and Mechanical Engineers, the Chesterfield and Midland Counties Institution of Engineers, the Midland Institute of Mining, Civil, and Mechanical Engineers, and the South Staffordshire and East Worcestershire Institute of Mining Engineers. These institutes had federated themselves for the purpose of holding joint meetings in various districts for the dissemination of mining knowledge, for extending their interests, and that they might appoint committees to report upon all subjects pertaining to mining. These were, he believed, the broad objects with which the Federation was commenced. He was sorry to say that all of the mining institutes had not joined in the Federation, but it was hoped that the day would soon arrive when those institutes would see that it would be to their great advantage and for the benefit of the mining industries of the country that the Federated Institution should embrace all. The institutes, however, in their individual capacity were not to be altered, and they would in their different spheres perform the functions they had hitherto done, and he thought these institutes had good reason to congratulate themselves on the success they had severally attained. If they

went back to the beginning of the present century and considered the state of mining at that time he thought they would come to the conclusion that these institutes and practical miners had developed the coal trade of the country in a very remarkable manner. He happened a few days ago to come across a manuscript of the late Mr. Buddle which would show them the position of mining in the year 1807. Mr. Buddle referred at that time particularly to Wallsend Colliery, with which he was connected. They were probably all aware that in former days, when working in shallow mines, pillars of coal were left very thin, but as the mining became deeper, the pillars of coal were left of the same thickness, the viewers or mining engineers of those days did not know or did not take into consideration the fact that the superincumbent strata were too heavy for these pillars to bear, and the result was that "creeps" were continually taking place, the pillars breaking down and the effect often being felt at the surface. It was on record that at Long Benton Church, when the parson was preaching one Sunday, bits of the ceiling came down, and the people began to be rather nervous. "It's nothing," he said, "it's only the creep in the pit; if you wait a bit it will be all right." But the congregation didn't "wait a bit," they began to creep out. These creeps affected ventilation, too, and the air currents were constantly being reversed. Here were Mr. Buddle's comments at Wallsend Colliery when the creep had upset the ventilation:—"Feb. 13, 1807.—Made some boxes to send some steam into the shaft to warm it with a view to restore the upcast, and got some large pieces of iron ready to heat, which are to be lowered down the shaft to assist the upcast. Feb. 14, 1807.—Applied the hot iron all day in the shaft, but without effect, as it continued to cast down, got the steam conveyed into the shaft, and continued it all night. Feb. 15.—Found the pit casting up this morning, and the following day got the pit to work." Now, all the gentlemen who knew anything about mining would know what a feeble current of air they must have had in those days. Fancy one of the largest and best collieries in the district being in the position of having only 3,000 or 4,000 cubic feet of air per minute! No wonder that explosions were very frequent about that period; so frequent indeed that the public took up the subject, and in 1813 it was recorded that a society was formed in Sunderland for the prevention of colliery accidents. It was taken up by the Duke of Northumberland, the Bishop of Durham, the Rev. Mr. Gray, the Rev. Mr. Hodgson (the historian of Northumberland), Mr. Buddle, by Dr. Clanny, and others. These gentlemen made several reports, and in one Mr. Buddle described the whole of the operations of mining, concluding his report in these words: "I think any further application of mechanical agency in preventing explosions would be ineffectual, and we must look to some method of producing such a change upon carburetted hydrogen gas as to render it innoxious as fast as it is discharged. In this view it is to scientific men only that we must look for assistance in providing a cheap and effectual remedy." Well, these gentlemen did apply to somebody; they applied to Sir Humphrey Davy, and in the course of two or three years, as was well known, they had the safety-lamp invented. This was the beginning of the mining institutes, and after that society had been so successful it

was disbanded, and nothing more was done in the way of scientific mining societies until the year 1852. Then an explosion took place at Seaham Collieries, and a number of engineers—several of whom were still living—founded the North of England Institute of Mining and Mechanical Engineers, which had continued from that time to the present. Other institutes sprang up in the different mining districts of the country, which had done most effective work, and had promulgated a scientific system of mining, which everybody must feel had been of very great advantage to this country. They hoped sincerely that the Federated Institutes would go on still further developing the wonderful art of coal mining. He thought they might still, as their old friends of 1813 did, go to scientific men, and say, "We want something still to prevent accidents, and we want something to increase the economy of working our coal mines." In what way progress would tend he did not know; it seemed to be pointing in the direction of electricity, but whether it would give them an electric lamp which would comply with the motto of their Mining Institute, "*Monco et munio*," or not he could not say. No doubt within the present century they would have a safe light for mines and we would have electrical tramways for cheapening the cost of conveying the coal underground and probably electric coal-cutting machines. Without further comment, he would call upon them to drink "Success to the Federated Institution of Mining Engineers," and couple with that toast the name of their worthy and venerable President, Mr. T. W. Embleton.

The toast having been duly honoured,

Mr. EMBLETON, replying, said he was not aware until he came to the meeting of the Federated Institution that he was to be their President for the ensuing year, and he must therefore be excused if he had not been able to collect his ideas for such an occasion as the present; but he hoped that during the time he occupied the position of President all the complaints that had been made would be removed, and that the Transactions would be regularly printed and punctually forwarded to each member of the Federated Institutes. They would receive all the papers read before the Federated Institution, and there would be this advantage, that they would find in those papers and in the discussions that would be published, the concentrated knowledge of all the institutes, which, if they were not federated could not be obtained without considerable trouble and expense. People nowadays called for their rights, and it was the right of each member of the Federated Institution that he should have reports of the meetings, whether they were held in Durham, in Yorkshire, in Derbyshire, or in Staffordshire. They would thus know in each district what appliances and improvements they had in the other districts. They would also have the advantage of knowing all that was being done at the home Institute, the originator, and, he thought, he might say the queen of all the other institutes, for it was their parent. He had been a member from the time which he called the year 1, which was a long time ago, and he might say he had not been altogether an idle member, for he had sometimes read little bits of papers which had given some information. The Chairman had recalled the state of mining, or rather of ventilation in the year 1807, but he did not think it had been from

personal acquaintance with mining at that time; in fact he probably had not appeared on the face of the earth at that time, for if he had he would have been two years older than himself. He did not know whether many of them could remember the time when they descended the shaft in the loop of a rope, guiding themselves with a stick to keep off the side of the shaft; he did not know whether even the Chairman was accustomed to that means of going down, but he himself was, and thought no more of it than of getting his dinner here. But where would they find the pitman, or the young mining engineer, who would venture down the pit now, as they used to do in those days? He thought they would not like it; whether their organization was more sensitive than in those days he could not say, but custom was everything, and if they accustomed themselves to a thing they might even come to like it. He remembered when cages were invented and a long time before they were introduced. The first beginning of cages was at a colliery near Sheffield about 1813, and he had a drawing and the specification of it. Mr. Buddle reported upon it. It was an ingenious contrivance, and he would try to describe it. There was a cage in a pair of guides and the rope was attached to the centre of the cage. Things were altogether different now, and if anyone could live for fifty years longer he had no doubt they would find as much improvement, or perhaps greater improvement, than had taken place during the last fifty years, and they would be entirely different from the labours of the members of these institutes; whoever thought of the fan or the many other contrivances? There was another thing; he hoped that as children were all better than their parents—a good deal better—that so the younger institutes would surpass the older. He thought it was only right to infuse fresh blood as the old hands were dying out; he believed there was only one gentleman present who could approach his own age. The old fellows had gone to make room for the young.

The MAYOR OF NEWCASTLE proposed "Success to the Coal Trade." As the representative of the Corporation—and through them of the people of Newcastle-upon-Tyne—he was deeply interested in the success of the coal trade of the counties of Northumberland and Durham. Their interests were identical; the welfare of the people, and of the city, was dependent on the prosperity of the trade in which the gentlemen present were also deeply interested. He believed he was right in saying, too, that the Corporation represented probably the oldest coalowners in the North of England; for the Newcastle Municipality, as coalowners, dated back to the time of Henry III., but, unfortunately for them, the royalty under the Town Moor not being recuperative was almost exhausted; they were still, however, interested in a very large royalty at Walker, and were partaking at the present time in the increased prosperity those present were also enjoying, through a large increase in their royalty rents. Being deeply interested in the welfare of this particular trade he had the greatest pleasure in proposing "Success to the Coal Trade," and in coupling with the toast the name of their esteemed friend Mr. R. O. Lamb.

Mr. R. O. LAMB, after acknowledging the toast, said those members of the coal trade who were junior to himself must have felt, as he did, great pleasure in listening to the remarks of the worthy President of the Institution, and he could only assure

him that they, in the North of England at all events, always liked to have the advice of their seniors, and when they could hear such remarks from a gentleman—who if not actually associated with Mr. Buddle, followed very quickly upon Mr. Buddle's heels—they felt their hearts warm towards him when they knew that the same spirit that actuated Mr. Buddle, also actuated his successors. It must be a matter of the deepest satisfaction to every coalowner to know that Northumberland produced such men as Mr. Buddle, who could feel sympathy with his fellows, and invoked the aid of scientific men to devise means for the saving of life; it was also a satisfaction to him and to coalowners to know that those associated with the management of their collieries were still following in the footsteps of their worthy predecessors. Year by year, if they compared the amount of coal produced in the United Kingdom with the number of lives lost, they would find the proportion of the latter decreasing, and he could only trust that this would continue. The progress in mining engineering had been great, and the progress in the production of coal had been enormous. If they took the last thirty-five years, they would see that the quantities were almost doubled; and unless scientific attainments had been brought to bear on the production of coal, and unless the coalowner had been most materially assisted by the mining engineer, he would like to know how they could have produced last year 170,000,000 tons of coal! Science had told most favourably upon the coal production of this country, and no doubt the problem for the future would be to produce coal cheaply. Unless they could produce it cheaply they would have great competitors abroad, and these might, though he hoped not, cause a considerable amount of trouble by their competition. How far the production of coal could be cheapened, and how far mining machinery was to supersede the strength of the human hand, were matters for the future. The President had spoken of electricity and electric lighting, but he had not referred to coal-cutting machinery; possibly that was a problem yet to be thought out, and if they did think it out and did away with the coal hewer, some gentlemen of science might do away with the coalowner. It was quite possible that if he were to express the somewhat uncharitable wish that the hewer should disappear some persons might also wish that the coal lessor and the coal lessee should also disappear with him. But how far science might change matters in the future, by electricity and other means of cheapening and increasing the production of coal, or by finding some substitute for coal itself, must be left for the future to settle. Meantime every colliery owner, whether a scientific man or not, and whether a member of this Institution or not, wished them all success in that which was, and must be, one of the highest aspirations of mankind, to lessen the loss of life and the number of accidents in mining, and also to increase the production of coal, and thereby to extend and sustain the reputation of this country to which it was their greatest pride to belong.

Mr. M. H. MILLS proposed "The Corporation of Newcastle," to which the Mayor and Sheriff responded.

Mr. A. L. STEAVENSON proposed "The Visitors."

Mr. JOSEPH MITCHELL, in replying, said he had often come to Newcastle, and on each occasion he had learned something—he had learned to-day that the beginning of

the coal trade was a very short distance from where they were at present meeting, and he was sure that all the mining engineers who came from the south were indebted to the North of England Institute for some very good advice, which they had received by becoming members of that Institute, or becoming associated with it, and through the perusal of its publications which were open to them. The North of England Institute was always pleased to communicate anything which would tend to their advancement. The electric light had to-day been referred to, and he always looked upon Newcastle-upon-Tyne as the sun shining on the coal trade; he hoped the sun might ever shine on Newcastle and on the coal trade connected with it, because if it shone at Newcastle, no doubt they in the south would have some of the reflection. He was very pleased, on behalf of the visitors, to return his hearty thanks for the way in which they had been received in Newcastle, and also for their reception of the toast. He could only repeat, what had already been stated before, that they would be pleased to see the members of the North of England Institute in the south, either at Barnsley, Sheffield, Chesterfield, Birmingham, or elsewhere. They would always find their doors open in welcome, and the oftener they came the more pleasure they would bestow.

The members then adjourned to the Durham College of Science where a Conversazione was given by the Principal and Professors of the College.

EXCURSIONS MADE DURING THE VISIT OF THE FEDERATED INSTITUTION OF MINING ENGINEERS TO NEWCASTLE-UPON-TYNE.

January 22nd, 1891.

The following collieries and works were, by kind permission of the owners, open for the inspection of members. The following notes record some of the features of interest seen by visitors:—

HARTON COLLIERY.—Double story heapstead; jigging screens; steel cleaning belts; gravitation roads at bottom of pit and on heapstead; tail-rope hauling engines on surface.

SAINT HILDA COLLIERY.—Similar to Harton Colliery; also Guibal fan. 50 feet diameter; patent fuel works; automatic expansion-geared winding engines.

BOLDON COLLIERY.—Similar to Harton Colliery; powerful winding engines, with automatic expansion gear; coal-breaking machinery for preparing splint coal for 15 mechanical stokers.

SEATON DELAVAL, NEW DELAVAL, AND NEW HARTLEY COLLIERIES.—Underground haulage (endless-rope and chain); surface machinery; coal washer and endless rope.

COWPEN, NEWSHAM, AND CAMBOIS COLLIERIES. — Mechanical screening; tub elevator; washers; coal-shipping spouts, harbour, docks, etc.

RYHOPE COLLIERY —Compressed air machinery, etc.

WINGATE COLLIERY.—Screening belt, etc.

BLAYDON MAIN COLLIERY.—Worthington pumping engine.

THROCKLEY COLLIERY.—Compound beam rotative pumping engine, pumping 2,500 gallons per minute.

TOWNELEY COLLIERIES, ADDISON PIT.—Two underground Hathorne-Davy pumping engines raising 2,200 gallons per minute. Endless chain from dip drift to surface.

ELSWICK COLLIERY.—Underground endless chain.

NORTH ELSWICK COLLIERY.—Evans' underground pumping engine, with steam at 100 lbs. to the inch.

NEWCASTLE AND DISTRICT ELECTRIC LIGHTING COMPANY'S STATION.—The equivalent of 8,000 ten candle-power lamps are coupled to the mains, and have worked for nearly a year without accident.

NEWCASTLE-UPON-TYNE ELECTRIC SUPPLY COMPANY'S STATION.

MESSRS. MILLS & SON'S BRASS WORKS.—Recently erected brass foundry, engineering and electrical works; manufactory of safety-lamps.

"NEWCASTLE CHRONICLE" PRINTING OFFICE.—Composing, stereotyping, and printing departments. The members saw a complete edition of the "Evening Chronicle" turned out from the first to the last operation.

THE GRAIN WAREHOUSES, Quayside.—The elaborate grain screening, cleaning, and other machinery were seen in operation.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
FEBRUARY 14TH, 1891.

MR. J. B. SIMPSON, VICE-PRESIDENT, IN THE CHAIR.

The minutes of the last meeting were read, and the proceedings of the Council meeting were reported.

The following gentlemen were elected, having been previously nominated :—

MEMBER—

Mr. Louis Irving Seymour, Mechanical Engineer, Chief Mechanical Engineer, De Beers Consolidated Mines, Limited, Kimberley, South Africa.

STUDENTS—

Mr. Nicholas John Bitzos, Mining Apprentice, Broomhill Colliery, Acklington.

Mr. George Chrisostom Zumbuloglon, Mining Apprentice, Broomhill Colliery, Acklington.

The following gentlemen were nominated for election :—

MEMBERS—

Mr. John Philip Kirkup, Mining Engineer, Singareni Collieries, Hyderabad, Deccan, India.

Mr. Syed Ali Belgrami, A.R.S.M., Director-General of Mines to the Government of H.H. the Nizam of Hyderabad, Deccan, India.

ASSOCIATE MEMBER—

Mr. Robert Henzell, Oil Manufacturer, Close, Newcastle-upon-Tyne.

ASSOCIATES—

Mr. Benjamin Mason, Mine Manager, Burnopfield Colliery, Hobson, Lintz Green.

Mr. Thomas Macintosh, Mining Engineer, Cowpen Colliery, Blyth, Northumberland.

Mr. John Shaw, Cramlington, Northumberland.

STUDENTS—

Mr. John Ritson, Mining Student, Marley Hill, Whickham, R.S.O.

Mr. William Mordy, Kimblesworth Colliery, Chester-le-Street.

Mr. Matthew Henry Kellett, Castle Eden Colliery.

Mr. M. WALTON BROWN read the following paper on "The Waddle Patent (1890) Fan":—

THE WADDLE PATENT (1890) FAN.

By M. Walton Brown.

The Waddle fan as manufactured prior to the end of the year 1889 is shown in Figs. 1 and 2, Plate XVII. It is an open running centrifugal fan, with alternating long and short curved blades fixed between and attached to two discs, one of which is pierced with a central orifice for the entry of the air from the mine. The pierced disc gradually approaches the other, in order that the products of the angular velocity at any distance from the centre of the fan multiplied by the area of the air channel at that point are constant, and by this means it was hoped that the fan would be kept full of air.

The Waddle patent (1890) fan is shown in Figs. 4 and 5, Plate XVIII. This fan is similar to those erected prior to the year 1890. In the old fan the air is discharged into the atmosphere at a somewhat high velocity, but in the new fan this velocity is considerably reduced by the addition of a divergent or trumpet outlet extending beyond the external ends of the blades.

The area of the outlet at the periphery of the fan is more than double of the area described by the external tips of the blades. Consequently the velocity at which the air leaves the blades is gradually reduced as it passes through the divergent outlet, and the air is discharged from the periphery of the fan at a low velocity into the atmosphere.

The law of the resistances varying as the squares of the velocities of the air suggests that the resistances at the outlet may be considerably decreased, that the capacity of the fan for the discharge of air may be increased, that the power applied to drive the fan may be diminished, and consequently that the general efficiency of the fan may be increased by the use of such an addition.

The volume of air (Q) discharged through an orifice (A) in a thin plate is given by the formula, $Q = \cdot 62\ A \sqrt{2gh_{(1)}}$; but it is well known that the volume passing may be considerably increased by the addition of suitable ajutages. Experiments on the issue of water through conical expanding ajutages of various forms and dimensions show that the value of the coefficient may be increased from ·62 to nearly unity. It may therefore be reasonably accepted that the divergent outlet applied to fans will have a similar effect in increasing the volume of air.

The long blades between the boss and the edge of the inlet ring of the fan are almost radial, and between the inlet ring and the periphery are arcs, placed at an angle to the radius, and may be adapted to meet the requirements of the mine to which the fan is applied.

The effect of the radial portion of the blade is to tend to produce equal velocities of the air in every part of the inlet, and to maintain a supply of air to the fan in excess of the quantity traversing the curved portion of the blades.

CRAGHEAD.—EXPERIMENTS UPON A WADDLE PATENT (1890) FAN, 35 FEET DIAMETER.

Date of Experiments.	August 23, 1890.						Aug. 6, 1890.	September 30, 1890.				
No. of Experiment	1	2	3	4	5	6	7	I.	II.	III.	IV.	V.
Conditions	Ordinary	Ordinary	Ordinary	Separation doors open	Ordinary	Ordinary	Ordinary	Ordinary	Ordinary	Ordinary	Ordinary	Ordinary
Revolutions of fan per minute	50·00	57·20	64·86	59·73	29·60	37·20	52·50	35·07	52·67	57·33	58·40	67·47
Revolutions of anemometer per minute	800·5	976·0	1124·0	1345·9	474·0	616·9	896·0	493·3	814·6	806·6	834·0	1000·6
Velocity of air in feet per minute (v)	795	964	1,104	1,312	475	617	887	494	809	801	827	987
Volume of air in cubic feet per minute (V = v × 176·3 square feet)	140,158	169,953	194,635	231,306	83,742	108,777	156,378	87,092	142,627	141,216	145,800	174,008
Water-gauge in drift in inches (h)	2·070	·410	3·157	2·671	·777	1·082	2·050	·855	1·934	2·390	2·526	3·274
Temperatures in air, wet bulb	52°	51°	47°	47°	47°	47°	*	56°	56°	57½°	55°	56°
,, ,, dry bulb	55°	56°	49°	49°	49°	49°	*	57°	57°	58°	57°	57°
,, in drift, wet bulb	54°	54°	53°	51°	53°	53°	*	54½°	54½°	54½°	54½°	54½°
,, ,, dry bulb	54°	54°	53°	51°	53°	54°	*	55°	55°	55°	55°	55°
Mean pressure of indicator diagrams in lbs. per square inch..	14·75	18·56	?	25·52	5·48	7·86	*	?	13·40	15·16	15·97	21·88
Weight of an inch of water in lbs. (a)	5·196	5·197	5·199	5·199	5·199	5·199	5·199	5·195	5·195	5·195	5·195	5·195
Horse-power in air (V × h × a ÷ 33,000)	45·68	64·50	96·63	97·33	10·23	18·51	50·55	11·72	43·44	53·13	57·98	89·68
Indicated horse-power— P × R × 446·87 sq. inches × 2 strokes × 3½ feet stroke ÷ 33,000 = P × R ÷ 10·549	69·91	100·64	?	144·5	15·38	27·72	?	?	66·90	82·39	88·41	139·94
Efficiency	·653	·641	?	·673	·665	·668	?	?	·649	·645	·656	·641

* Not observed.

To illustrate Mr. M. Walton Brown's paper on "The Waddle Patent (1890) Fan."

1889 FAN.

FIG. 1.

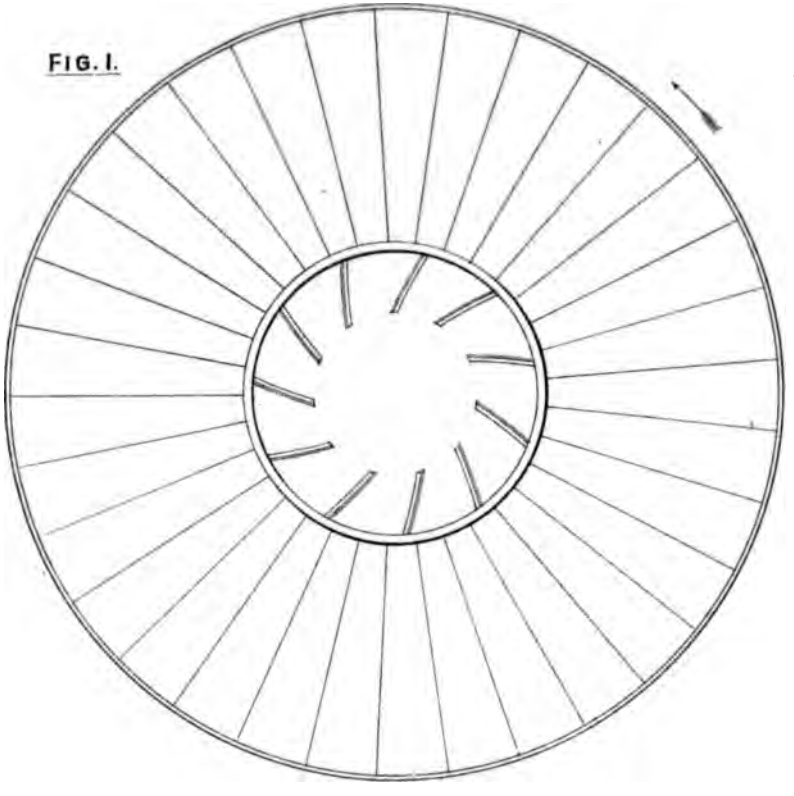


FIG. 2.

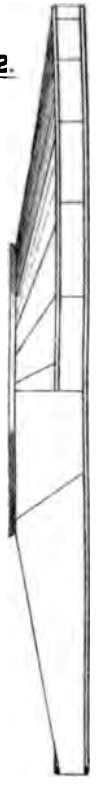
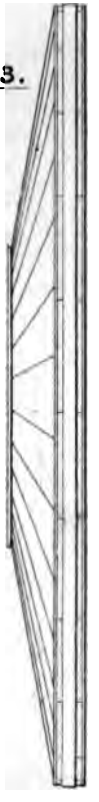


FIG. 3.



To illustrate Mr. M. Walton Brown's paper on "The Waddle Patent (1890) Fan."

1890 FAN.

FIG. 4.

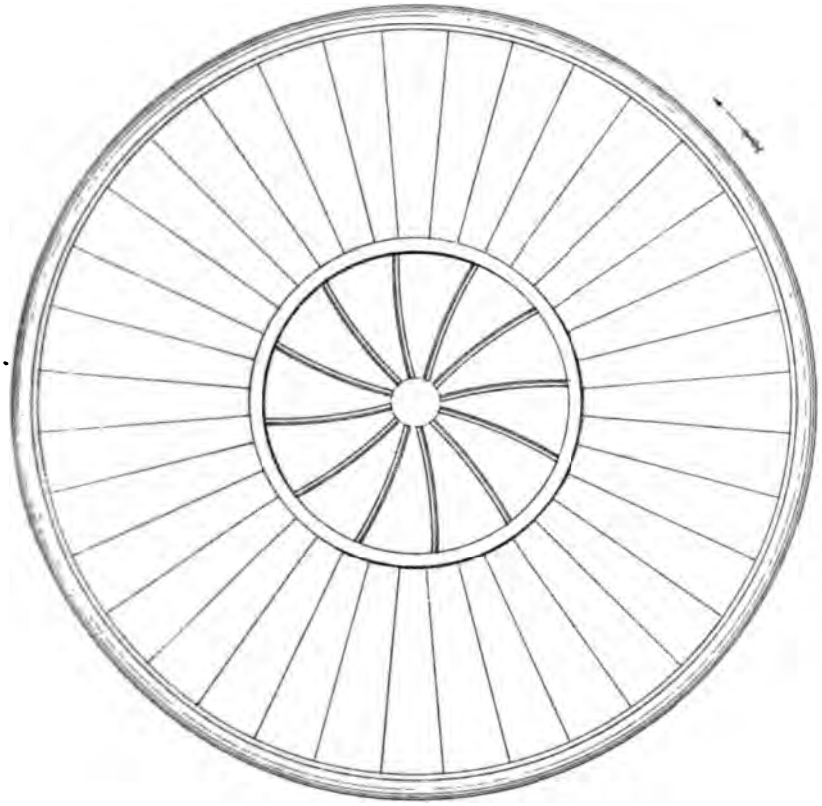
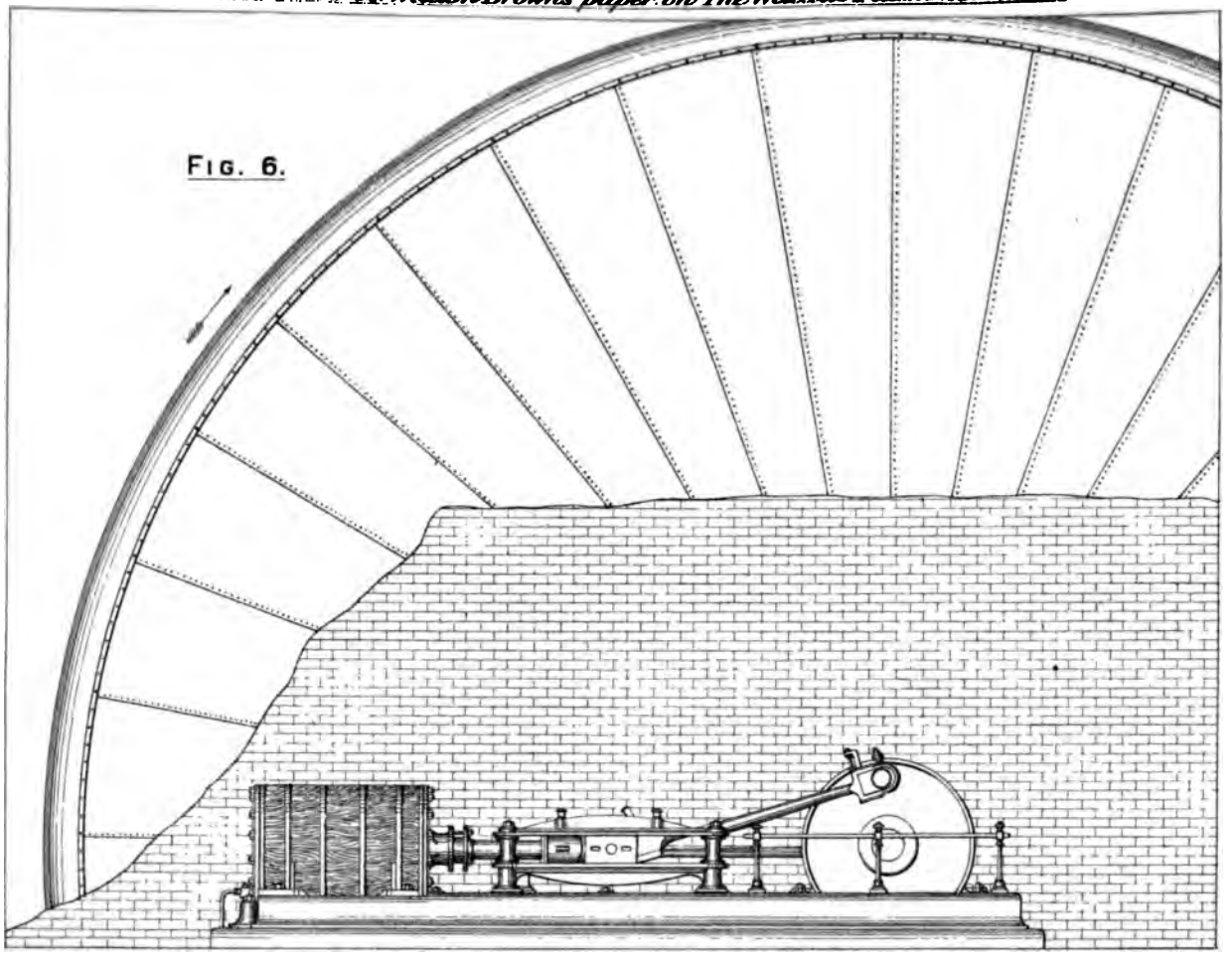


FIG. 5.

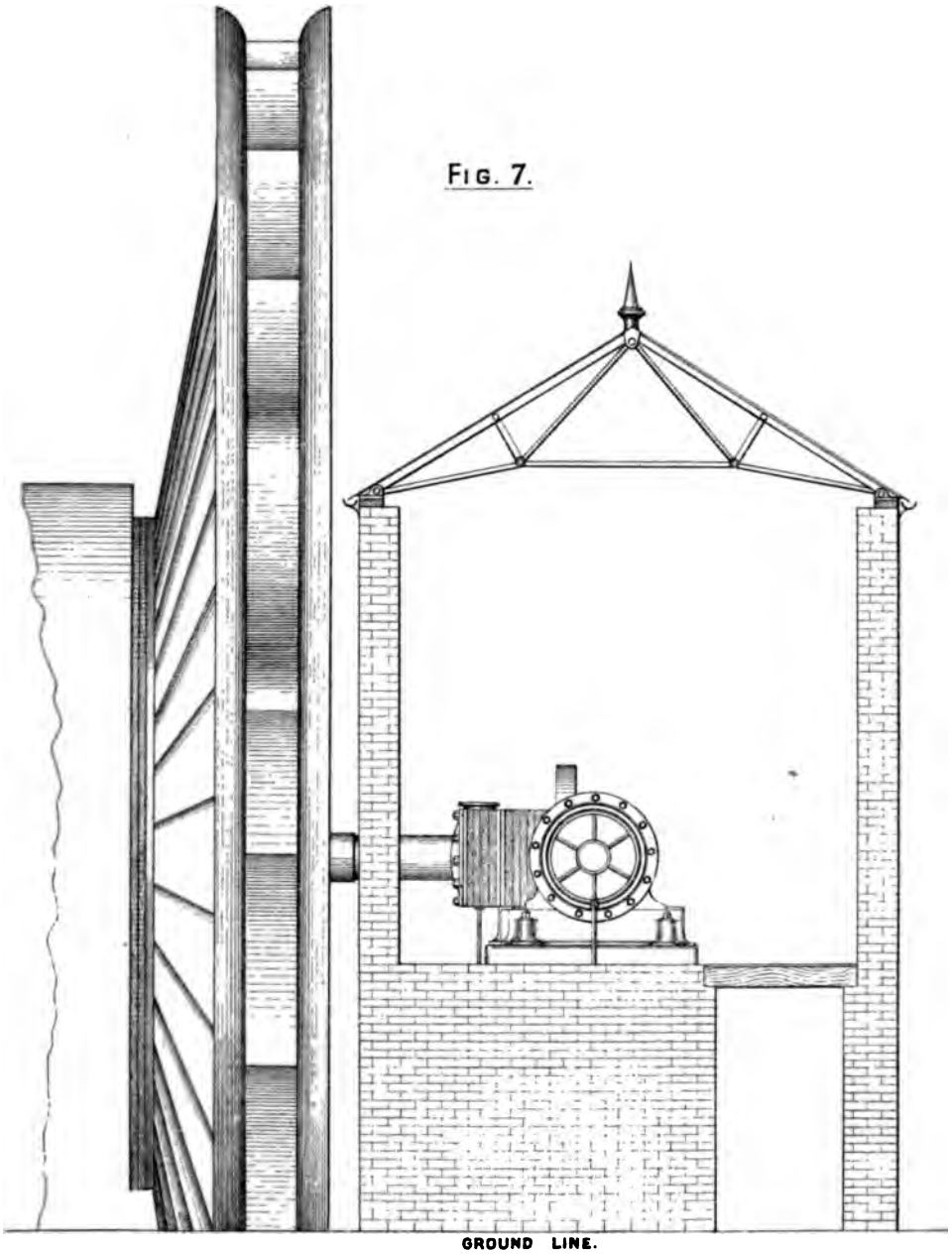
To illustrate Mr. M. Walton Brown's paper on "The Waddle Patent [illegible]"

FIG. 6.



To illustrate Mr. M. Walton Brown's paper on "The Waddle Patent (1890) Fan".

FIG. 7.



A Waddle patent (1890) fan was erected at Craghead Collieries, and through the courtesy of Messrs. Thomas Hedley & Brothers, and their agent, Mr. James Fairley, a series of experiments were made by the writer to determine its efficiency.

This fan is delineated in Fig. 6, Plate XIX., and Fig. 7, Plate XX.; its dimensions are as follows:—

	Ft.	Ins.
Diameter to periphery of divergent outlet	36	4
Diameter of the extremities of the blades	35	0
Diameter of inlet ring	13	6
Width at outlet	1	1¼
Width at periphery of fan	2	2¾
Capacity of fan	2,583 cubic feet.	

The fan is driven direct by one high pressure horizontal engine, with ordinary slide valve, and variable expansion valve, cutting off between ¼ and ⅜ stroke, as required. The cylinder is 24 inches diameter, and 42 inches stroke: the piston rod (at front end only) being 3¼ inches diameter.

During the course of experiments 1 to 7, there were three downcast shafts, whose air was exhausted by the Waddle fan; and during experiments I to V the air was derived from two downcast shafts, instead of three as in the previous experiments.

Four seams of coal are worked at the Craghead Collieries: the Shield Row Seam at a depth of about 56 yards, the Five-Quarter Seam at 78 yards, the Main Coal Seam at 100 yards, and the Hutton Seam at a depth of about 168 yards.

Mr. A. L. STEAVENSON said he did not think they were in a position to discuss the paper at any length that day; it would be better to wait until the results of the experiments were in the hands of the members. He understood the diameter was rather more than 35 feet as given in the paper; if so it would make a difference in the results from the water-gauge, for the water-gauge varied in accordance with the square of the speed of the periphery. The results seemed to be very excellent, and fully equal to anything he had met with, and if they were correct—and no doubt they were so far as Mr. Brown was concerned—it was a very excellent fan.

Mr. HUGH WADDLE said in the old fan the blades were only a short distance within the inlet ring; consequently when the fan was of larger capacity than the mine the air was taken in close by the inlet ring all the way round, and the blades struck the air at a high velocity. Now, by bringing them towards the centre, as shown in Plate XVIII., the air struck all parts of the blades equally under the same conditions; through the blades radiating from the centre, the air was so hurried up them that the main volume would come from near the centre of the fan; but when the fan was working up to its full capacity the air was brought forward equally over

the whole inlet area. The radius of the blade was also varied to suit the water-gauge and the requirements of the mine; it was altered for every water-gauge. The divergent outlet was not generally applicable to the improvement of the old type of Waddle fan, but in cases where the capacity of the fan was greater than that of the mine, he recommended the addition of his patent band shown in Fig. 3, Plate XVII.

Mr. WALLAU asked if the inventor had any exact data as to the actual gain through curving the inner ends of the blades as described?

Mr. WADDLE said he found that these curves required to be altered slightly according to the velocity of issue of air from the fan.

Mr. WALLAU asked if the blades of any fan had been altered?

Mr. WADDLE said he had tested one fan with and without the divergent outlet. After applying the divergent outlet, they found an increase in the volume produced and power utilized of about 20 per cent. When they stood opposite the outlet of the old fan, the stream of air from it could be felt at a considerable distance, but with the new fan the effects of the issue of the air were not noticeable even at a very short distance.

The CHAIRMAN asked if old fans could be altered in accordance with this principle without much trouble?

Mr. WADDLE—We cannot get good results by the addition of the divergent outlet to an old fan, as all the proportions of the fan require to be altered.

Mr. J. A. RAMSAY said if he understood the matter aright a new fan of small size would give results equal to a larger one of the old construction.

Mr. WADDLE replied that the same results could be obtained with a smaller fan of the new design; the proportion as near as possible being that a new 35-feet fan will give nearly the same volume of air as the old 42-feet pattern of fan.

Mr. C. C. LEACH asked why the blade kept was short of the periphery of the divergent outlet?

Mr. WADDLE said if the blades were carried to that periphery there would be re-entry, which it was the very means of stopping. The blades must get air from somewhere, and as the capacity of the fan at the circumference where the blades stop was so much less than at the outlet, the blades if extended as proposed would have to draw in the outside atmosphere to feed themselves.

Mr. M. WALTON BROWN said a question might be asked as to the diameter of the fan to be used in making reductions and calculations. It appeared to him that the effective diameter of the fan would be the diameter of the tips of the blades, that was 35 feet. So far as the action of the divergent outlet was concerned, it might be compared to the expanding chimney attached to the Guibal fan; and except as regards mechanical difficulties it might be a fixture and would produce the same effect with the fan running inside and just clear of it. He would like to hear the views of the members as to which diameter of the fan should be taken in reducing the results to those given at the normal velocity.

Mr. WADDLE said that no work was done beyond the tips of the blades; there was no increase of centrifugal force after the air left the blades. The divergent outlet had the effect of reducing the speed of the air rapidly as it passed into the larger area. The area being more than doubled between the inner and outer end of the divergent outlet, as a consequence the velocity of the air was reduced to at least half-speed.

Mr. R. L. WEEKS asked if an old fan had seven inches cut off the blades in the inside would there be any beneficial effect?

Mr. WADDLE replied that the results would not be improved, the water-guage at the same number of revolutions would be lowered, and the change would simply produce a fan of smaller diameter.

Mr. J. A. RAMSAY said that the alteration suggested by Mr. Weeks would not be beneficial, as the shortening of the blades of an old fan would have a deterrent effect.

Mr. LEACH asked what part of the efficiency was due to the divergent outlet?

Mr. WADDLE said that point depended upon the volume of air being passed. If there was a very small quantity of air in relation to the capacity of the fan a very large proportion of the additional power utilized would be due to the alteration of the blades; if there was a very large volume of air, a much larger proportion of the efficiency would then be due to the divergent outlet.

Mr. H. AYTON enquired as to the effect that would be produced by attaching a divergent outlet to an old fan?

Mr. WADDLE said that in the trials already mentioned there was a difference under the two conditions of about 20 per cent.

Mr. T. E. FORSTER asked if better results were obtained by the divergent outlet or the band applied to an old fan?

Mr. WADDLE said if the old fan was giving a fair volume of air he would recommend the divergent outlet, but if the capacity of the mine was much less than that of the fan he would certainly recommend the band.

Mr. A. L. STEAVENSON said he had one simple little rule he always applied to fans:—$D^2 \times R^2 \div 800{,}000$* which gave the theoretical water-gauge in inches, and the nearer they could approach the theoretical result the nearer they were to perfection. The Guibal fan gave as high as ·67; the new Waddle fan seemed to give ·60, if they took 35 feet as the outer diameter. However, if the diameter of 36½ feet was taken, the results were still very good. He understood that the end of the water-gauge when the vacuum was read was close to the inlet of the fan, which was acknowledged to be rather a strong advantage in favour of this fan. He considered, after a recent visit, that the Waddle fan at Craghead Colliery was a strong fan, very simple, and not likely to get out of order. It was an excellent fan from a mechanical point of view, and the useful effect appeared equally favourable.

* D being diameter and R revolutions of fan per minute.

Mr. M. WALTON BROWN said, with regard to the useful effect of ventilating fans, he thought that one point had frequently been overlooked; he alluded to the efficiency of the engine. A fan might be erected, for which the maker claimed 70 or 80 per cent. of useful effect, and the efficiency of the fan was entirely neutralized by attaching it to an engine and boiler consuming say 15 lbs. of coal per horse-power in the air! Another fan, of inferior design, might yield the same results from a consumption of 5 lbs. per horse-power in the air. That is to say, one fan might consume coal to the value of £400 per annum, while a more efficient fan, in consequence of the attached inferior engine and boiler, might consume £1,200 worth of coal per annum.

Mr. WADDLE said if they used an engine of too high a class they would be apt to get into difficulties; they wanted a simple engine which would utilize a good proportion of its power. They might have an engine which would use less coal, but the main saving after all was at the boilers.

Mr. BLACKETT, referring to Mr. Brown's remark on the place at which the diameter of the fan should be measured, said his conviction was certainly in favour of measuring its diameter at the tips of the blades.

The CHAIRMAN said he would propose a vote of thanks to Mr. Walton Brown. They were always glad to have new appliances brought to their notice if they showed any improvement on those at present in use; but they were also specially thankful on this occasion, as when they found that there was no business for this meeting, Mr. Brown kindly came forward at once and offered to read this interesting paper.

Mr. T. W. BENSON said he had much pleasure in seconding the vote of thanks. He was sure they must all feel obliged to Mr. Brown for supplying so interesting a paper.

The vote of thanks was cordially adopted.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
APRIL 11TH, 1891.

MR. W. COCHRANE, PRESIDENT, IN THE CHAIR.

The minutes of the last meeting and the proceedings of the Council were reported.

The meeting heard with very great regret of the death of Mr. John Marley, a former President of the Institute, and unanimously adopted a vote of condolence with the family.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. John Philip Kirkup, Singareni Collieries, Hyderabad, Deccan, India.

Mr. Seyd Ali Belgrami, A.R.S.M., Director-General of Mines to the Government of H.H. the Nizam of Hyderabad, Deccan, India.

ASSOCIATE MEMBER—

Mr. Robert Henzell, Oil Manufacturer, Close, Newcastle-upon-Tyne.

ASSOCIATES—

Mr. Benjamin Mason, Burnopfield Colliery, Hobson, Lintz Green.

Mr. Thomas Macintosh, Cowpen Colliery, Blyth, Northumberland.

Mr. John Shaw, Cramlington, Northumberland.

STUDENTS—

Mr. John Ritson, Marley Hill, Whickham, R.S.O.

Mr. William Mordy, Kimblesworth Colliery, Chester-le-Street.

Mr. Matthew Henry Kellett, Castle Eden Colliery.

The following gentlemen were nominated for election :—

MEMBERS—

Mr. D. Selby Bigge, 27, Grey Street, Newcastle-upon-Tyne.

Mr. Joseph J. Henderson, U.S. Engineer's Office, Kingsbridge, New York, U.S.A.

ASSOCIATE MEMBER—

Mr. John Hunt Hedley, John Street, Sunderland.

ASSOCIATES—

Mr. Edward Griffith, High Street, Coedpoeth, Wrexham.

Mr. William Parkinson, South Moor, Chester-le-Street.

Mr. WM. COCHRANE delivered his presidential address as follows :—

PRESIDENTIAL ADDRESS.

By Mr. W. Cochrane.

The position in which you placed me in August, 1890, is one which I feel to be the highest honour you can confer, and which I hope it is the ambition of many of you to attain—for it should indicate a previous diligent attention to the work and interests of the Institute to carry it on prosperously. It is with the assurance that I am here as the expression of your satisfaction with me, and that I have your sympathy and aid to support the dignity and duties of this office, that I ventured to enter upon it. An apology is due to you for having absented myself immediately after my election, owing to the condition of my health, and my thanks are due to the Vice-Presidents and members of Council who have fulfilled my duties.

In attempting to address you, as is usual, I do so with great diffidence. Previous presidential addresses seem to cover most of the ground available, and it cannot be expected that each year should develop anything strikingly new or interesting. Now that the office is annual, it might perhaps be desirable to expect only every third or fifth year's President to sum up the advances of the previous term of years. Had such a system been in operation, my lot might have fallen, fortunately for me, upon one of the silent years. A few points which have occurred to me may suggest matter for your consideration and investigation—if so, my object will have been gained. Referring to the date of 1863, when the British Association met in this city, Lord Armstrong, subsequently our President in 1873, reviewed, in his inaugural address, the previous quarter of a century. He laid particular stress on the increased output of our collieries which, in 1861, had reached 86,000,000 tons, and estimating the then known coal-fields as workable to a depth of 4,000 feet, he gave less than 100 years as the probable exhaustion, if the production continued at its then rate of increase. He gave at the same time a warning of the wasteful use we were making of coal—not attaining more than one-tenth of its calorific power in the best, and probably only one-thirtieth in the average of our steam engines, losing two-thirds of that heating power in nearly all manufacturing processes; and using for domestic purposes about five times as much coal as would produce the same effect in properly constructed stoves. He urged economy in the processes of getting coals as well as of consuming them. An earlier warning had been given by our first President in his address of 1852, an address which I advise all our members to peruse. It is a record of the state of mining engineering in almost all its details in his time—he having had the benefit of an experience of forty years, thus carrying us back to 1812. The Proceedings of our Institute may well be referred to as recording the successive achievements due to the Mining and Mechanical Engineer, and the forty years since Nicholas Wood addressed the Institute, may be compared as having accomplished at least as much as his predecessors of forty years had done,

thus fulfilling the wishes of himself and the other founders of this Institute, which were and still are our highest aim. Can we also say, as Lord Armstrong said in 1863 of the twenty-five years which he surveyed, that in mechanical science the progress made in the quarter century "has no parallel in history?" The British Association met again in our city in 1889. I think its proceedings will show that in every department of mechanical science the last quarter century has not been behind the previous one in development, for the science of electricity has made such extraordinary progress as to rival in its application and utility even the application of steam power, upon which it is at this stage largely dependent, but there are indications of its economical production without the intervention of steam, and its use for the transmission of power appears to be capable of such extension as to be in some directions the necessary economical development of steam power. I refer to the opinion of one of the leading engineers of the day, Sir F. Bramwell, who, in his address to the British Association at York in 1881, stated as his opinion that in 1931, when the centenary of the British Association would occur, they would find that the steam engine had become a curiosity, and was relegated to museums, for he could not believe steam would continue to be the vehicle for transmitting heat into work. This he repeated at Bath in 1888, and saw no reason for withdrawing it.

We have, however, to deal with the present conditions of the uses of coal, and it may be worthy of our attention to review the various opinions expressed as to the duration of our resources. In the second volume of our Transactions a communication is made by G. C. Greenwell, in which he estimates from 1846, a period of 331 years' duration of the Northumberland and Durham coal-fields, with an annual demand of 10,000,000 tons, which he considered might be attained. In 1854, T. Y. Hall estimated 256 years, with an output of 20,000,000 tons annually.

I do not find any further mention of this subject till 1863, in Volume XII., when Messrs. N. Wood, J. Taylor, and J. Marley came to the conclusion that such an investigation could be of no practical utility, and that the attempt for a vast period of time was, at the least, premature. In Volume XXXII., 1883, the subject was very fully gone into by G. C. Greenwell, who indicated at least 230 years; and in Vol. XXXVII. a valuable summary of estimated durations is given up to the year 1882.

Having now reached, in 1890, an output of nearly 40,000,000 tons of coal in the counties of Northumberland and Durham, it seems to me desirable that some allusion should be made to such altered conditions, so that the records in our Proceedings may not be misleading. In 1865, Professor W. Stanley Jevons brought the subject before the public in his work on the *Coal Question*, and with such investigation of details that a Parliamentary Committee was formed in 1866 to enquire into the matter—their report was issued in 1871—the general conclusion being that there was an available quantity of 97,525,000,000 tons, and they estimated a duration of 350 years. Professor Jevons had suggested 110 years, each period being based on the conditions of seams being workable at a depth of 4,000 feet, and of

eliminating all coals less than one foot thick. A more recent investigation in 1889 has been made by Price Williams. It has the additional light of another quarter century thrown upon the data of the 1866 Committee, and we are brought by his estimates to face a possible exhaustion of the coal-fields in this country within a century. Long before then some districts will be practically shut out from competition in the struggle for existence, and the industries now settled there and dependent on cheap fuel will migrate to other centres. Take, for example, the Cleveland iron trade, which is one of the chief consumers of the Durham collieries' output. It will expand, or at least continue its present production as long as the Cleveland ironstone holds out, and cheap fuel is available. Sir Lowthian Bell, in his report to the British Association in 1863, "On the Manufacture of Iron in connexion with the Newcastle and Durham Coal-fields," estimated that the whole of the available coal in the Durham coal-field was just sufficient to smelt all the valuable ironstone of Cleveland. There are other inferior ironstone seams, but it is doubtful whether on the exhaustion of the Main Seam competition would be possible with other markets. The exhaustion in ninety-four years of the coal supply in Durham, as estimated by Price Williams, would mean, therefore, the cessation of the iron industry.

In the Midland Counties, where coal and ironstone seams are found under similarly favourable conditions, a shorter duration of the coal-fields, seventy-two years, is estimated by Price Williams.

In each case, taking into consideration the small output of such thin seams as one foot, and at depths approaching 4,000 feet under the difficult conditions of temperature and the enormously increased outlays and working costs, it seems to me that the extent of working will be of a very limited character, and that a closer approximation to the wane, not the exhaustion, of the coal industry in Great Britain, will be to estimate seventy-five years hence rather than 100. Most of us, probably noting the spread of the black coloured areas, indicating goaves on the working plans, have been engaged in considering how long our own particular collieries may be estimated to last—there are few, I think, can suggest even fifty years—while the tracts of unopened coal-fields are few, and at increased depths will present the difficulties previously indicated to development. The output of 181,614,288 tons of coal in Great Britain for 1890, the largest output attained, is an increase upon that of 1889 of 4,697,564 tons, slightly exceeding 2½ per cent. per annum, which was the average rate of increase over the previous fifteen years, and is the rate of increase on which Price Williams bases his estimate of the period of exhaustion. It is rather startling to consider that such important industries may within the space of a lifetime be narrowed so as not to be any longer features of the districts where now they are the chief.

This question of the duration of the coal may be considered an unnecessary scare, but it should urge us more than ever to economize its use. What has been done in this respect since the warning of 1863? In domestic consumption, I fear that none of us can say we have to any important extent reduced our coal bills,

although the type of fire-grate with fire-brick sides and back, the latter overhanging the fire bars, is unquestionably an improved form. Some credit must also be taken for the extended application of heating houses and public buildings by air heated by slow combustion stoves, by gas stoves, and by the circulation of water in pipes—considerable economy in fuel being the result—and making the open fire-place so essential to our ideas of architecture as well as of comfort, a luxury instead of a necessity.

In the raising of steam and in the application of it there have been great advances. Boilers are now constructed which evaporate as much as 12½ of the theoretical 15 lbs. of water with 1 lb. of coal. Instead of exhausts at high pressure wasting into the air, the employment of condensers yielding at the same time pure water for the boilers and enabling economies in the steam cylinder by the use of the vacuum, are general in a modern well appointed plant—thus reducing the boiler power required—while the adoption of triple and even quadruple expansion is one of the chief features of modern steam engine designs. The compounding alone resulted in an economy of about 40 per cent. of fuel. The triple expansion is about 20 per cent. better than the compound. The original single high pressure cylinder required about 3½ lbs. of coal per horse-power per hour—the triple expansion only 1½ lbs. Higher pressure of steam and higher expansions are more generally adopted. In some collieries, to meet the varying loads in winding shafts, variable expansions have been adopted, but fuel is generally too cheap to encourage the use of this otherwise economical arrangement; its use will extend as greater depths of shafts are involved.

Notwithstanding the improvements indicated, we are very far from having utilized the nine-tenths of the theoretical effect which we were told we were wasting, and this condition should lead us to investigate closely how so serious a loss can be avoided. It seems as if it cannot be in the direction of steam as the motive power—for it is in the application of steam, and not in the production of it, that the serious loss arises; but it may come in that of electricity. Successful research is being carried on in the obtaining of currents by the mixing of positive and negative gases, of which hydrogen and oxygen are examples, upon the principle that the electrical force which separates the constituents of water is produced and is capable of being economically stored and used by combining them. Carbon monoxide (the cheap production of which is effected by the passing of steam over incandescent fuel and other gases) as well as liquids, are available for the same purpose.

One more allusion to the economizing of our coal supply is necessary in the working of the seams. It is incontestable that great waste, now irrecoverable, has taken place in previous years, both underground and on the surface; and even now in seams where dirt bands occur, as is especially the case in the Midland Counties, the expense attending the separation of the good coal, when very thin, leads to the leaving it underground; in some of the four-feet seams as much as 15 per cent. being cast back into the goaf, and even in mines when the highest prices have ruled

for coals, it has not been found profitable to draw it out of the pits and prepare it for the market. This may be an extreme case, but in the ordinary working of coal seams at least 6 per cent. of the whole of the coal is left underground, which is so much fuel lost to the country. This should induce every possible economy to prevent the loss.

Mention should be made under this head of the important works carried out in the South Staffordshire coal-field, where a fresh lease of life has been secured by combining to recover drowned-out collieries; it is a new feature in mining operations, and one which is worthy of imitation. Over an area of 72 square miles works have been carried out under and above ground by the Mines Drainage Commissioners, so as to displace the operations of single collieries which were no longer able to deal with the quantity of water which, by the working away of barriers, found its way to them; and by a concentration of pumping engines, and drainage works, to re-open much of this area, which contained valuable tracts of the 30-feet seam, as well as lower coal and ironstone measures. Instead of 139 pumping engines in 1872, raising 48,000,000 gallons of water per 24 hours, much of which, after having been lifted to the surface, soon found its way down again through the broken strata owing to the fissured condition of the undermined watercourses and rivers, 17 engines are employed raising 17,000,000 gallons per 24 hours, and these are steadily reducing the level of the water throughout the mines affected, while the cost of raising 25,000 gallons of water 100 feet high, which was previously 11d., at the best plant in this district, is now only 3¼d. The Commissioners are a body elected by the colliery owners and lessors, receiving no remuneration. They levy rates under their Parliamentary powers, according to evidence laid before them, as to any colliery which benefits by their operations—if by surface works, a rate of 1d. per ton on the output of minerals, and if by underground operations, 6d. to 9d. per ton.

Similar combinations for the economical working of various industries seem to be a feature of our time, those having reference to the distribution of motive power being of primary importance, for they cheapen its production and enable small users to economize in a manner which, in the case of the establishment of a separate plant, would often preclude the adaptation. Take, for instance, the supply of compressed air as in Birmingham, where pipes convey air at an average pressure of 45 lbs. to the square inch, which can be turned on by a valve, day or night, by any consumer. A district of that town, of about four square miles, is so supplied. Boilers with risk of explosion, and chimneys with the accompanying dirt and smoke, are dispensed with; a very slight alteration is needed to an engine previously using steam—the charge is by meter—a minimum of 4d. per 1,000 cubic feet of air at 45 lbs. pressure per square inch, taking at least 4,000,000 cubic feet per quarter-year, and a maximum of 1s. 8d. per 1,000 cubic feet for a consumption as low as 50,000 cubic feet per quarter-year. With a well-arranged engine about 125 cubic feet are used per indicated horse-power per hour, and with the use of expansion,

and by heating the air, an economy is effected which results in the cost per indicated horse-power per hour of ½d. in the case of consumption equivalent to 4d. per 1,000 cubic feet, and 2½d. where it is 1s. 8d. per 1,000 cubic feet.

I must refer to another form of motive power, similarly distributed as that of compressed air—the hydraulic—which has attained a large development in London and elsewhere. Street mains are charged at 700 lbs. per square inch, and service pipes are laid on wherever required; hydraulic lifts are thus possible for lofty houses and stores without the necessity of repeating costly plants, and the estimated cost of its use is as low as ¼d. per ton, lifted 50 feet high. Its application is of the most varied kind, and among others for hydraulic riveting of girders in the construction of some of the bridges across the Thames, where the great facility of carrying the riveting machine to any point where it is required, effects important economy.

Extensive plants for providing electricity for lighting are also being employed for providing motive power, but at present there are no large applications in this direction, most of the plants being established by the separate users. An important and rapid development is being made in this direction, but there is much to be settled as to the useful effect of this agent as a motive power, however useful it may be under special circumstances. When such a result is recorded as a loss of 85 per cent. of the horse-power generated at a fixed station in propelling a railway car, and the best result in pumping water is about 40 per cent. of the indicated horse-power of the steam engine, there is much to be discovered before its use can be economical and its destiny be achieved, to become, as is believed, the motive power of the future.

In other countries favoured with rivers and waterfalls, the application of water as a motive force has, during the last few years, been developed to a large extent, and the hydraulic distribution carried out in a similar manner. At the Trollhätten Falls in Sweden, the Schaffhausen in Germany, and at the outlet of the Rhone from the lake of Geneva, we have some of the finest examples; the beauty of the scenery is sacrificed, but the utilization of force is gained. At Geneva, by an arrangement of turbines sunk in chambers at the level of the bed of the river, a motive force is developed of about 6,000 horse-power, each turbine giving about 300 horse-power, and is applied by cranks to forcing engines which maintain a hydraulic pressure of 200 to the square inch in mains laid along the streets of Geneva, for service to factories and houses. Machinery is driven by this means, and the town is provided with electricity produced from the same power.

The transmission of the power from the turbines, actuated by the waters of the Rhone, gave rise to many practical tests to obtain the most economical system of distribution. Wire rope cables, compressed air, and electricity, were proved to be inferior under the conditions of Geneva city to the hydraulic pressure, which yields 50 per cent. of the power generated by the turbines. Each system may be advantageously applied under different conditions. At Schaffhausen, the wire-rope transmission was first adopted, but is giving way to the electrical. In Geneva the

water is supplied from the same mains for household consumption. This use of hydraulic power has been of the greatest importance to the city. Fuel had become so expensive an item in the use of steam power that the industries for which Geneva had been celebrated had seriously declined. This cheap provision of power carried to every workshop in the town has restored its prosperity, and enables it to compete with the markets of the world in its specialities. Transmission by electricity is contemplated in an extension of the Geneva works at the junction of the Arve and the Rhone, owing to the increasing loss of power due to the frictional resistance under hydraulic pressure.

It may be thought that I have taken a gloomy view of the future of our country in suggesting so early a decline of our coal industry, but other causes may help us to extend the period of our ability to compete in the industries of the world. No industry has had a more extraordinary development than that of petroleum. The boring of wells was commenced in America only about 1859. American oil found its way rapidly into all the markets of the world for illuminating purposes; it supplied the cheapest and most useful form of light. Gas and electricity have their special recommendations, but for universality of application and for portability, petroleum is not excelled.

There is an interesting account in our Transactions, by the late E. F. Boyd, of the American oil district which he visited. At that date, only one other region, Gallicia, had been opened, and that only to a small extent.

In 1884 there were about 4,000 miles of American pipe lines from the petroleum wells, along which the oil was pumped to various railway stations, and these pipe lines and pumping machinery form some of the most extraordinary works which engineering science has succeeded in perfecting. I refer, as an instance, to a direct pumping main of 70 miles length of 5-inch pipes, and to another where oil was pumped a distance of 110 miles with one pumping engine. It is estimated that 75 per cent. of the power applied was expended to overcome the frictional resistances. Generally, the pumping stations are 30 to 40 miles apart, and through a 5-inch pipe about 150 gallons per minute may be delivered. This mode of delivery has enormously reduced the cost of transport, previously by rail to the sea, in tanks, so that now the price of refined oil, in Europe, is about what the cost of transport alone was by rail to New York, and the refining has passed to the large towns where the various products of crude petroleum are of value, instead of being lost as they were at the oil wells.

The American source of petroleum seems to be defined over an area of about 3,000 square miles, at depths of 1,000 to 5,000 feet. It occurs mainly in two sandstone beds below the lower productive Coal-measures, and yields about 1,000,000,000 gallons per annum, or about one-half the production of all the oil districts. In 1890 about 500 wells were bored per month—an average well yielding about 6,000 gallons per day. In exceptional cases a well has yielded as much as 10,000 gallons per day. The average life of a well has been about two and a half years.

The subsequent discoveries of petroleum in the Baku district have eclipsed those of America, and the supply of Russian oil has spread over the world in an

extraordinary manner. The perusal of Mr. Marvin's work, entitled the *Region of the Eternal Fire*, will well repay any of you who wish to inform yourselves on this interesting subject. An area of about 15,000 square miles seems to be saturated with petroleum, and to yield enormous quantities by borings. Oil springs are found at an average depth of 150 feet, the oil being under great pressure; in one case discharging to a height of 300 feet above the surface, under a pressure of about thirteen atmospheres, and yielding 2,000,000 gallons per day. A well at Baku in one day yielded almost as much oil as 25,000 borings in the American petroleum district. This yield is the striking difference between the two districts—10,000 to 25,000 gallons per day being the average yield of a well in the Baku district, and showing no diminution over several years. Also, deeper borings prove other oil springs, whereas the American zone of supply is limited.

A vast industry has sprung up in connexion with the Baku petroleum. In 1880 about 2½ million barrels of 360 lbs. each, and in 1888 16½ millions, were the yield of that district. Tank steamers are being increased in capacity and in number to carry the refined oil in bulk. Large storage reservoirs, into which the oil is pumped from the steamers, are constructed at various centres—there is an important one on the River Tyne for its distribution throughout the north of England.

Its use is being steadily enlarged, especially as metallurgical fuel. The product, after refining, called astatki, about 70 per cent. of the original raw oil, is used in steamers and locomotives in Russia, instead of coal; its price is only about 4d. per ton at the wells. With cheaper railway connexion from the wells to the seaboard, it will be found available even in this country as fuel; it is much more cheaply carried and stored than coal, and may materially assist in delaying the date of the exhaustion of our coal-fields; one ton of it is equal in calorific effect to two tons of coal; but with existing appliances 5 to 7 lbs. are required for 1 horse-power in steamers, and only 12 to 13½ lbs. of water are evaporated for 1 lb. of astatki, but better results will no doubt be attained with larger experience of its use. For the same bulk, one-fifth more weight of astatki is stored than coal; it burns smokelessly; stokers are dispensed with, and there is neither ash nor clinker produced. Already it is used exclusively on the Caspian, and is finding its way into this country. It was sold at 2s. 6d. per ton in the Caspian district at a time when English coals were £3 15s. per ton.

Discoveries of as great importance as at Baku are being made east of the Caspian, on the line of the future railway system to India, the value of which is self-evident. In the Punjaub, in China and Japan, in Canada, and in many other quarters of the globe there are also petroleum supplies.

It may be interesting to quote the opinion of geologists as to the formation of coal and petroleum, the former being the result of air-fed vegetation, such as trees, reeds, ferns, mosses, the latter of water plants, and hence the origin of fluid petroleum in the sands and shales of the Devonian age in which submarine vegetation was as rank as the terrestrial vegetation of the coal epoch. Oil deposits are found in nearly all the beds from the base of the Coal-measures into the Devonian series, and bitumen, from a similar but marine vegetation origin, is found in Silurian limestones.

In reviewing the engineering progress which has been made in recent years, I think none is more conspicuous than that in the department of what is called Sanitary Engineering. I hold that this is intimately connected with the calling of the Mining and Mechanical Engineer, and must be recognized as a branch of our profession. Our district is particularly fortunate in having among the earliest of similar associations one which has done, and is doing, good work. The health of a district and of a town may be affected by the condition of a single house. It is a duty, therefore, of every householder to apply the most modern systems to prevent the outbreak and spread of disease. Arrangements no less scientific than those involved in properly laying out and ventilating a mine, are required for the ventilation of buildings, and of drains and sewers. It must be within the experience of everyone of us that even in modern houses, sewers and drains are formed without regard to the most elementary principles, and often without any record of them on a plan; while a main drain has been often used as a reservoir for sewer gas, with accumulated pressure against the house connexions, ready to break through any imperfect joint or water trap, instead of being a delivery pipe free from the possibility of obstruction and certain in its action, which should always run itself clear, and by suitable ventilating appliances be constantly circulating fresh air. Among many important improvements in this direction, compressed air has been successfully applied to the transport of sewage. A similar application may be found useful and economical in underground drainage. By this system, known as the Shone process, the sewage flows into tanks, so fitted that, when a certain level of sewage is attained, a valve is opened and compressed air of the required pressure is introduced by an inlet-valve connected with an air-pressure main; the inlet sewage valve in the tank closes automatically; the sewage is forced to the delivery outlet along any length of pipe and height of lift as may be required for reservoirs or for irrigation of lands. It will be seen that instead of large gravitating sewers, often constructed at great depths to overcome undulations of surface and the accumulating services in its length, each tank may have its service of gravitating pipes of small diameter, and, therefore, better flushed, and these, as well as the delivery pipes from the tanks, need only be at small depths below the surface. The use of cast iron pipes, instead of that of earthenware or brick-built sewers, makes the work more permanent and less liable to damage from settlings of the ground. A central air compressing plant provides the power which can be carried to any part of a town where the tanks are fixed. The system is particularly applicable to low-lying and flat towns, and is in successful operation at Rangoon, as well as in several towns in England.

In mines where small feeders of water occur at long distances from where provision exists for dealing with them, or where gravitation can only be obtained, if at all, by expensive drifts and cuttings of levels, this system may be found preferable to the employment of wire ropes or the use of steam, air, or hydraulic engines.

I feel that I have trespassed too long upon your patience. I will conclude by reverting to my opening subject, and suggest that it seems to me that there should be

no short-sighted policy on our part to hoard the stores of fuel and ironstone we have in this country, but that we are doing the best service in our time by developing our mines to the utmost with all our accumulating skill as engineers, and supplying, with open hand, the needs of all the countries that require our products. We use our experience for the general benefit, and improve our own position simultaneously, increasing work in all departments of our industries resulting from increased development of the coal and iron industries. When the old country is on the wane in these respects, we have vast colonial resources, where our engineers are already finding scope for their professional careers. It is a happy coincidence that in our colonies, where we settled owing to very different attractions, we are finding valuable coal and ironstone deposits. The experience of the old country is being applied to their engineering works, and it may reasonably be expected that better results will follow than under the difficulties which its attainment with us has involved, whilst it must not be forgotten that the prosperity of the Empire, so dependent on that of the colonies, is our aim. Some satisfaction may be felt that as an industrial centre the old country may continue to hold an important place in the world by the economies as yet unrealized in the use of liquid fuel, yielded from our own strata and to be imported from so many countries, and the production through its agency of power (whether electrical or other) sufficiently cheap to enable the manufacturing industries to flourish, owing to the favourable position of Great Britain for importing from all parts of the world the materials required, and to the increasing energy of the engineer to keep himself to the front in the competition for pre-eminence.

Mr. G. B. FORSTER proposed a vote of thanks to the President for his very interesting and lucid address, to which they must all have listened with pleasure. They were glad to welcome Mr. Cochrane home again, and the address showed that in his absence he had not neglected to inform himself of what was doing in this and other countries.

Mr. LINDSAY WOOD said he had pleasure in seconding the motion. Mr. Cochrane must have devoted great attention to the subjects treated of, which were well worthy of investigation by the members of this Institute.

The vote of thanks was cordially adopted.

The PRESIDENT thanked the members for the manner in which they had received the few notes he had put together. He thought he might after the event say that he had been in a prophetic mood, as the paper they were now going to hear from Mr. Steavenson was a development of the suggestion that some of the matters he had referred to were well worthy of their consideration.

Mr. STEAVENSON then read his "Notes on the Present Position of the Question of Transmission of Power."

NOTES ON THE PRESENT POSITION OF THE QUESTION OF TRANSMISSION OF POWER.

By A. L. Steavenson.

In the course of three months' time this Institute will enter upon the fortieth year of its useful labours. And yet, with the single exception of 1886, a search through the index of our volumes does not show that such a vitally important question as the transmission of power has ever occupied its attention; in that year we find Messrs. Liddell and Professor Merivale read a paper upon the "Transmission of Power by Steam."

No doubt the subject has been raised incidentally at various times, but never in a way worthy of its importance, and yet, often when the writer has urged friends, especially the younger members, to assist the Institute, benefit themselves, and give the world a taste of their quality, the almost invariable reply has been: "Yes, we should be glad to do so, but really the whole of the ground has been so fully covered that there is nothing left to write about." The fact is, thoroughly well-made experimental work, or the results of any long and fully grown experience in working, is always valuable;—and instead of the ground being already covered, it is hardly yet fairly opened. When our Secretary wrote a few weeks ago saying he was short of a paper for the present meeting, this subject, which had been, during the last three years, very prominently brought under our notice by our electrical friends, who seem determined to carry all before them, and to leave all other modes of transmission in the remote past, appeared to be an appropriate one. It also appeared proper to collect and place on record our present position, and then if these gentlemen persist in treating all other systems as hopelessly beaten, we may, at least, possess some standard to judge them by, and they, some accurate data, upon which to base their claims.

Hitherto we have been content to use, 1, steam; 2, compressed air; 3, hydraulic power; 4, ropes.

The writer does not propose to give only his own experimental work, but also to record what has been done in well authenticated instances which have come under his own observation.

Steam.

Of the use of steam, he does not propose to say much, for long experience has led him to think that it is always wasteful and very hurtful underground, and it has become his fixed rule never to take steam there; he has repeatedly, and with great advantage, brought engines to the surface, and carried the ropes down the shafts, and this, he believes, is a very common experience—it being much easier to carry ropes than steam. He has, at the present time, seven engines on the surface hauling or pumping, and with electric bells they work just as readily and efficiently as they

could do below; the recent demands of labour have shortened all hours of underground work, ordinary datal time and overtime run up very fast; repairs in the dark are troublesome, and expensive to make; engines when buried out of sight are apt to get neglected and dirty; steam must be maintained all night and over the week-end in the pipes, or if not, when it is again turned on, the joints are broken, causing more expense, and quite needlessly; so, under all circumstances, we may say—steam in the mine is like dirt—"matter in the wrong place."

Compressed Air.

This medium, in spite of all that has been said against it of late, as being costly, holds the field for remote distances underground; if it escapes through bad management, unlike steam or electricity, it is an unmixed good, affording a supply of cold fresh air. For many years it has been largely used by the writer, having in one case in Cleveland seven miles of pipes, where it is used for Walker's rock drills (fully described by the writer in Vol. XXXI. of the Transactions, page 105.) Of course, as is there shown, it requires to be used with a proper recognition of the laws which govern its action, proper cooling arrangements being made in the shape of water-injection during compression in the air-cylinder. Few accept this necessity and the majority pay the penalty in a small useful effect; but for twelve years past the adoption of this system has proved its value, and, in fact, without such means, the work which has been done could not possibly have been accomplished. For those who have not studied the use of compressed air M. Pernolets' work, *L'Air Comprimé*, a bulky volume of a most perfect kind, is strongly recommended.

Compressed air has been for sometime distributed through Birmingham by a company got up for the purpose, and when the writer was there last autumn he took the opportunity of going over the works. He found two engines and compressors working, and 4½ miles of pipes were said to be in use, fourteen works being supplied at rates varying from 4d. to 1s. per thousand feet at 45 lbs. pressure.

With a capital of £150,000, as it might be expected, the scheme has been carried out with every effort to attain the highest possible perfection. Boilers of a sectional water-tube pattern were heated at first by the water gas process, but this on the occasion of our visit had been abandoned (gasifying the fuel at a distance from the point of utilization, and thus losing the radiant power of the solid fuel as well as the heat which escapes during transit through underground flues, having proved apparently to be a mistake). The main engines are on the triple expansion compound condensing system, of which the high-pressure cylinder is supplied with steam at 140 lbs, reduced to 45 lbs. in the second, and 3 lbs in the last. But inasmuch as the compressed air was allowed to leave the compressors at the full heat of compression, and the number of customers was small, the prospects to the writer did not seem promising.

Previous to the commencement of this company a very interesting printed scheme was got up by the engineers discussing very fully the problems involved; it is published by Messrs. Spon, and is well worth perusal.

Such of us as attended the meetings of the British Association in Newcastle in 1889, heard a very interesting paper and discussion upon the Parisian Compressed Air Co. In this case, the effects of cooling in the compressors, and reheating before use, are stated to have raised the efficiency to 50 per cent. In the *Engineer* for May 3rd, 1888, where a very full description of all these interesting works is given, it is stated:—"The Compagnie Parisienne de l'Air Comprimé claims that the indicated horse-power on the motors amounts, when worked expansively, to 87 per cent. of the effective horse-power represented by the compressor's diagram."* With the plant at that period in operation it is said to have a revenue of £36,000, the air being sold from 14·875 centimes for ¼ horse-power to 4·95 francs per 12 horse-power per hour, and in *Engineering*, March 13th and 20th of this year will be found a further paper on this Parisian system, giving some wonderful results from heating the air before using it: thus it will be seen (page 327), "from these results given in this table, very carefully carried out by Professor Gutermuth, that more than 70 per cent. of the total number of the calories in the fuel employed was absorbed by the air and transformed into useful work. Whether gas or coal was employed, the amount required is so small as to be scarcely worth consideration; according to experiments carried out it does not exceed ·09 kilogrammes per horse-power per hour."

Professor Weyrauch† has also carefully investigated this part of the subject, and fully confirms, if he does not go beyond, Professor Gutermuth. He claims that the efficiency of fuel consumed in this way is six times greater than when burnt under a boiler to generate steam.

According to Professor Riedler,‡ from 15 to 20 per cent. above the power at the central station can be obtained by means at the disposal of the power users. He says further: "The efficiency of this type of rotary motor, with air heated to 50 degs., may now be assumed at 43 per cent., that is, with small two horse-power rotary motors, some of the others, even old and with imperfect designs, give results much higher, losing only 8 to 10 per cent. in their own friction"; and from these results Professor Riedler deduces, assuming 85 per cent. efficiency, a consumption of from 600 to 720 cubic feet per brake horse-power; and he considers that results so favourable cannot be given by any other means of transmission.

The writer has also for many years found the very great advantage of heating the compressed air, being thus able to do work with air first cooled by water spray in the compressor, far beyond what was possible by the machinery employed, had such means not been employed, a few pieces of old timber from the "broken" workings of the mine being all that was necessary to maintain the heat in the old vertical boiler used for the purpose.

Of course, such heating cannot be adopted in mines, except in very exceptional cases, where the machines are near the shaft bottom, as in the writer's own case, or at Normanton; where the celebrated electric pumps are working; but if reheating cannot be used in the face of a coal mine, neither should a sparking electrical motor,

* *Engineering*, May 1, 1891. † *Engineering*, May 1, 1891. ‡ *Engineering*, April 10, 1891.

In the case at Normanton just mentioned, where compressed air was abandoned in favour of electricity, the air was not cooled, the engine was attached direct to the air cylinder, and as the value of this treatment of the air is still disputed, it may be well to show how clearly it depends upon laws about which there cannot be any mistake.

If we calculate the power to produce one foot of compressed air at four atmospheres absolute, or, as we say, 45 lbs. above the atmosphere, we find that for isothermal compression, *i.e.*, with temperature constant by means of water injection, we require 12,048 foot-pounds.

But if, as is commonly practised by our rule of thumb men, we allow it to be done adiabatically or without abstraction of heat, then we require 15,672 foot-pounds,

and $12{,}048 \times 100 \div 15{,}672 = 76{\cdot}87$ per cent.,

showing difference in favour of isothermal compression at that pressure of no less than 23·13 per cent.

Is that not worth saving, and does it not account for the bad repute into which the system has fallen, a bad repute which can be attributed to nothing but the crass stupidity of English engineers?

Wire-Rope Transmission.

This system has been referred to on various occasions by the writer, amongst others, but as experience is daily accumulating, it will still bear investigation. There are three descriptions:—

1. The ordinary—as used in mines, and only differing in the class of driving pulley.
2. The teledynamic, unknown almost in this country, and the
3. Rope driving in substitution for belts.

Of this latter it is not proposed to say anything; it would alone afford scope for a useful paper.

In the year 1864 the writer found it necessary to substitute some better mode of dealing with large quantities of water than the horizontal rods or spears then working. He turned his attention to ropes, and from information received, he learnt that at Woodhouse Close, then a large colliery near Bishop Auckland, he would find under the late Mr. Richard Heckels the most advanced and complete method in operation: Mr. Walton, now engineer at the Brotton Mines, being in charge of the machinery. There he found that, after the work of hauling was finished for the day, the ropes were coupled to drums, and upon the shaft of these were attached the pumps, the engine being reversed by the man in charge each time the length of the rope was run out. This seemed to require an unnecessary amount of attention, and as the Fowler clip-sheave was just introduced instead of drums at Upleatham Mines for haulage purposes, being reversed each journey, these sheaves and a system of continuous running was adopted by the writer for the first time. During the twenty-seven years which have since elapsed it has been abundantly proved that, with proper care, and everything as it ought to be in good order,

no other means has yet been discovered to do the work more satisfactorily in every respect, under circumstances such as prevail in mines, except where hydraulic power can be made available. Thus Mr. Geipel in his paper before the Institute of Mechanical Engineers says: "Wire rope is perhaps cheaper for distances of less than one mile," which conditions are, to a great extent, such as we have to deal with. At all events, it much more than covers the distance dealt with at Normanton, of which we have heard so much, and Professor Osborn Reynolds in one of the Cantor Lectures before the Society of Arts, says:—"Experience with ropes is large, and they have been found without question the most efficient mechanical means of transmitting powers to long distances."

But, as facts, especially if recently obtained, are better than the opinion of witnesses, however eminent, the writer has just repeated tests, frequently made before, upon a pumping plant (that short word is much to be preferred to the jaw-breaking installation—one syllable to four), at the Carlin How Mines in Cleveland.

There with the steam engine, 14¼ inches diameter × 3 feet stroke, on the surface, with a 5-feet Fowler sheave geared 3 to 1, the endless rope is carried down the shaft 25 fathoms to a double-acting 7-inch pump, which draws the water at the suction end 59 yards, and forces it up to another pit and out to the surface 568 yards. The distance of the pump from the engine is 455 yards, and from the standage or sump to the delivery 627 yards.

The gross height pumped is 135 feet, above the pumps 132·35 feet. This, of course, is equal to a statical pressure of 56·91 lbs. But although the pipes are 6 inches in diameter it is found that the friction of the long range and bends increases the load up to 62 lbs. when acting, and this makes the work done equivalent to pumping against a vertical column (as at Normanton) of 146·83 feet.

The tests were made in the writer's own presence and he can verify every item.

Diagrams were taken:—

1. With the clack doors off so that engine, sheaves, ropes, and pumps were running at the usual speed, but no water moving.
2. Engine, ropes, sheaves, and pumps running and lifting water at the usual speed.
3. Engine, ropes, sheaves, and pumps with a second pump attached, which works daily, and of course adds to the working load and cost, especially of the rope, but beyond testing the usual gross load upon it, this was not carried further.

The following results were obtained at 41¼ revolutions of the engine:—

	Indicated horse-power.
No. 1. Both pumps working and usual load on the rope ...	14·03
No. 2. Main pump only	12·71
No. 3. Ropes, engine, sheaves, and pump, but clacks off ...	5·99

Water measured on the surface during No. 2 experiment, 127 gallons per minute.

It is manifestly fair, when a pump is forcing water through a great length of horizontal pipes, in addition to the vertical column, that the resistance which is overcome in horizontal friction should be credited to the work done, if it is to be compared with that of a pump which is merely acting in a direct lift up a pit. Therefore, if the working load be taken as shown by the pressure gauge, then :—

	Feet.
Column above pump	144·20
Suction below do.	2·35
Total column	146·55

Now 127 gallons raised this height is equal to 5·64 horse-power, and 5·64 × 100 ÷ 12·71 = 44·37 per cent. of useful effect.

The ropes, sheaves, and pumps were in their usual working condition; just as they have been running for years.

The average life of the ropes is found to be about three years.

The last put on June 5th, 1889, still working in excellent order, is thus entered:—"Fathoms, 455; 2¼-inch circumference; plough steel, 25 cwts. 1 qr.; £73 4s. 6d.; the previous one having been put on September 21st, 1886."

These ropes, as we have seen, have to work the load of both pumps, and the average cost of all stores except coals, but including ropes, was found to be for a period of three years, £40 17s. 5d. per annum, or about 1d. per horse-power per working hour.

Teledynamic Transmission.

This system of conveying power at the enormous speed of 60 miles an hour, has been brought to great perfection on the Continent, where, of course, in many districts coal is a scarce and expensive material, and when the writer went to the south of France two years ago he made it his duty to visit Schaffhausen, and another system at Geneva to be mentioned hereafter.

Schaffhausen, in Switzerland, where the falls of the Rhine are utilized, is said to be the largest transmission, and Messrs. Hirn send "500 horse-power along a ¾-inch rope, and that the loss per mile is only 1·4 per cent., while with the electricity it is nearly 6 per cent., so that, as regards weight of conductor and efficiency, the electric transmission is far inferior to the flying rope. Nor is this all; the loss at the ends in getting the power into and out of the rope is 2½ per cent., whereas, in experiments by M. Deprez, 30 per cent. was lost in the electric machinery alone, and no account was taken of the loss of power in the transmission to and from the electric machinery."*

Turbines, 9½ feet diameter, are driven by a fall of 12 to 16 feet of water, and are capable of developing many hundreds of horse-power. The ropes are carried over grooved pulleys 15 feet diameter, running at an average speed of 100 revolutions per minute; the tension to transmit 326 horse-power is, according to M. Achard, 5,807 lbs.† Mr. Hirn showed that by this system 120 horse-power may be transmitted 12½

* Professor Osborn Reynolds, M.A., F.R.S., Cantor Lecture to the Society of Arts.
† Proceedings of Civil Engineers, Vol. xlix.

miles, and that, notwithstanding the loss by usclessly expended power, 90 horse-power remains available at the remote end. The driving wheels are as light as is consistent with strength.

Since that time the new aluminium works of Lauffen-Venhausen have been established. They are on the site of old ironworks, which the supply of cheap power could not maintain against the cost of transport of raw materials.

By a concession of the municipality of Schaffhausen in February, 1889, the Aluminium Industry Company, Limited, acquired the right to draw from the Rhine, above the falls, 20 cubic metres per second, which, at the height of the falls, estimated at 20 metres, corresponds to 4,000 horse-power. Their works were in progress of construction, but too incomplete for inspection.

The turbines constructed at Zürich, are of sufficient power to drive three dynamos, two of 600 horse-power and a third of 300 horse-power, the supply pipes of the 600 horse-power turbines being 1·4 metres and for the 300 horse-power 1·1 metres, the former being constructed for a maximum volume of 3,150 litres and 225 revolutions. Of the success of this venture the writer has yet no information, but if power forms any considerable feature in the cost of the manufactured article, it should do well.

Geneva.—Hydraulic Power.

Advantage was taken on the occasion before-mentioned to spend a day and night at Geneva, and a card with the inscription, "Utilisation des forces motrices du Rhone. Mr. Steavenson est autorisé à visiter les turbines," was easily obtained.

The river flowing from the Lake Leman, where it has deposited all its dirty and foreign matter, divides Geneva into two portions, and, under the direction of Colonel Turrettini, works have been constructed suitable for 20 turbines of 210 horse-power each. There were at that time 15 working. One arm of the river (which is divided by the Rousseau Island) has been left to carry off the water as before, but the water of the other is carried into a building erected on the bed of the river containing the turbines.

The turbines pump the water to a reservoir of 2,000,000 gallons capacity upon a hill about 2½ miles from the town, and this water, at a pressure of about 13 atmospheres, is utilized to drive motors in the town. There were then about 216 motors working, and varying from one-third of a horse-power for sewing machines up to 625 horse-power used for the electric light. The scheme was said to pay handsomely, and certainly it is one which, for practical common-sense, must command the respect of every one who has any experience in the utilization of motive power. This, although not directly of interest to us, leads to a few words upon hydraulic distribution in our own towns.

Hydraulic Distribution.

Hull appears to have the credit of the first adoption of this system of distributing power to general consumers, where it was adopted in 1875, and its success there led to its adoption on a larger scale in London, where, in 1882, the General Hydraulic

Power Company got to work, the site chosen for their works being the Falcon Wharf on the south side of the river. The power is supplied at 700 lbs. per square inch, the boilers are of the double-flued Lancashire type, and engines, compound, inverted, of the three-cylinder type, high-pressure cylinder 19 inches, and two low-pressure cylinders of 25 inches each, with a stroke of 2 feet. In the description given by Mr. Edward Bayzand Ellington, C.E., to the Institution of Civil Engineers, he says they had, in 1888, four of these engines working at the Falcon Bridge Station (each capable of exerting 200 horse-power), two accumulators, and the weight of the case and load on each ram being about 106 tons, equal to 750 lbs. per square inch. The water when used under this pressure requires to be purified to prevent injury to the surfaces in contact with it, and this is effected by filters consisting of cast iron cylinders each containing a movable perforated piston and a perforated diaphragm between which is introduced a quantity of sponge, compressed by hydraulic pressure from the pipes; the delivery of power from this station is by four 6-inch mains, and the most distant part was over three miles from the accumulators. A charge on a sliding scale is made varying from 2s. to 8s. per 1,000 gallons at 700 lbs.

It is stated that "in many cases the cost of lifting by the company's power is as low as one halfpenny per ton, lifted 50 feet high."

In a letter from Mr. Ellington, in answer to the writer's enquiries, he says, "At the present time we have about 1,300 machines at work, and are delivering over five million gallons of power-water per week, we have nearly 50 miles of mains; in Liverpool also we are making very satisfactory progress."

Hydraulic Transmission for Mines.

When water has to be raised to the surface it sometimes happens that there is not shaft room for the ordinary pumps with their well-balanced quadrants and spears, perhaps a great depth makes them unsuitable, although where they can be used nothing can approach them for economy in working; then pumps have to be placed in the mine. In this district steam engines have been used, in others electricity, and in others hydraulic power; under such circumstances, this latter, the writer is inclined to think, may have a few competitors but no equals.

One of the most interesting cases is that described to the Institution of Engineers and Shipbuilders in Scotland, in 1882, by Mr. Jos. Moore, C.E., of San Francisco.

It was on the Comstock Lode, and the writer tells how one big engine after another at various mines was beaten; they seem, however, to have made the mistake of trying to work heavy pumping engines with fly-wheels "in order to make the motion steady and take up the momentum of the moving parts," hence the writer is not surprised to learn that both fly-wheels had their arms jerked out, and every balance-bob in the shaft was broken from the spear rods, but still, when they required to pump from a depth of 3,200 feet, and the Savage Mine struck a large body of water (160° Fahr.) at the 2,200 feet level, their misfortunes were not all of their own seeking. The three mines joined hands, more engines were put up,

but 1,180 gallons from such a depth of water at that temperature again beat them, and then it was suggested to raise the water by hydraulic engines without any pump rods at all; they had to pump 1,600 gallons per minute from the 2,400 feet level to the 1,600 feet, and 800 additional from the 3,200 to the 2,400. A description of the machinery is not needed here, but for the hot joints a copper ring turned up at the edges and filled with soft lead was found very effective; the pumps were said to be then raising 1,600 to 1,700 gallons per minute, and the engine developing (in actual water pumped,) a duty which compared very favourably with the best mill engines in California. The proportion of power developed by the engine pumps, that is, the water pumped and the water consumed in the hydraulic ram cylinders, was as 1,856 to 2,050, or 90·5 per cent. This is evidently an excellent and very creditable engineering performance.

Mr. Henry Davey, of Leeds, has also as an engineer done some excellent work in the designing and construction of hydraulic or water-pressure engines for mining purposes. An interesting account of his work and experience may be seen in a paper he read to the Institute of Mechanical Engineers, in 1880, where he describes several pumping plants working most successfully in mines. An example is given of two engines at Griff colliery, near Nuneaton, employed to pump out a very long dip working; there are two hydraulic engines, each capable of raising 150 gallons to 150 feet through 800 feet of 7½ inch delivery pipes. Several other instances of this most efficient system of underground pumping are given, with drawings and descriptions of the engines, pumps, and valves.

To the Society of Arts (see their Journal, Jan. 29, 1886) the same writer has given an account of a still more interesting arrangement designed by him, at Marseilles. In a gallery, which is subject to inundation, are placed two hydraulic pumping engines, delivering the water into the drainage gallery of the mine. At the surface is placed a compound condensing engine, actuating two double-acting pumps, from which water is carried at a pressure of forty atmospheres. This water is not discharged into the mine, but returns again through a second pipe to the pumping engine; the effective pressure is the pressure produced by the pumping engine on the surface. M. Biver, the engineer at the mine, has taken indicator diagrams from the steam engines, the pumps, and hydraulic engines, and has measured the quantity of water pumped; he gives the following figures:—

Pressure in supply pipe at prime mover	42 atmospheres.
„ „ hydraulic pump	57 „
Pressure in return pipe	15 „
Revolutions of prime mover	22
Double strokes of hydraulic pump	5·12
The total efficiency of the whole system reaches	54·2 per cent.
The total work of the steam engine was	229·2 H.-P.
Work done by hydraulic engine	124·2 H.-P.

Here we have an eminently safe and most economical system of transmission.

Electrical Transmission.

We now come to the latest invention for power transmission, and one which is certainly the most interesting. Everyone who has devoted attention to the subject must have felt that, under conditions suited to its use, it would be found to have very unusual powers and value. Unfortunately, it seems to have fallen into the hands of injudicious friends, who would hear of nothing but electricity in each and every case, and having treated the question as one to be beyond the reach of any dispute, have boomed and advertised it like a ruby mine or a patent soap.

Let us take the very latest intelligence from the *Electrical Review* of March 6th. There we find that Mr. Kapp has been giving a lecture to the Society of Arts. He supplies a table showing the cost of plant: in a variety of cases varying in distances and in horse-power. If we take that nearest to the rope transmission at Carlin How, we find that for 19 horse-power transmitted 440 yards the cost for generator, dynamo, line, and motor would be £390 or £16·8 per horse-power, which is just twice the cost of rope transmission. The latter would easily supply the 19 horse-power in the case quoted, for the average steam pressure in the cylinder at Carlin How does not exceed 10 lbs; in fact, given clip sheaves a foot larger, and a slight increase in the size of the rope, the plant would do the work of another case cited as costing £640 for 40 horse-power the same distance. Then we are told that the commercial efficiency is 78 per cent., this is a repetition of a statement that the writer showed some time ago to be so misleading as to be barely honest, because, as "commercial efficiency" is commonly understood, it means the power A could sell to B, in comparison with the indicated power of his engine, or the power that, say, the London Hydraulic Co. sell to their customers in comparison with the indicated horse-power of their own engines. But that is not what electricians are dealing with, they compare the horse-power of the motor with what they put into the dynamo from the belt. At least so it was in some much-vaunted tests known as the Kriegstetten experiments in March, 1887. The writer was one who in *Engineering* pointed out this possibly unintentional perversion, and we heard later that the learned professors who made the experiments "smiled at the preference given by practical engineers to mechanical power tests." Of course such gentlemen in their own laboratories may use what tests and descriptions they like, but when they put them before the world cloaked in expressions such as "commercial efficiency" they should know that practical men understand by such a term as "commercial" that it has a well recognized meaning, and to call the work done in the dynamos by that term is quite unwarrantable.

Well, to return to the leaderette in the *Electrical Review* of March 6, 1891: notwithstanding this commercial efficiency of 78 per cent. "this company at Schaffhausen charges £13 12s. per horse-power delivered per annum, which is considerably less than steam power in the district." It may be less costly than steam power in that district, but if so, it is not a district to which the writer would be drawn as suitable for the erection of any kind of factory requiring power. Let us, however,

look a little nearer home to electrical power in collieries. We have learnt through the columns of every journal in England of the work done at Normanton. These announcements have been repeated in American papers, translated and put into Continental papers, and then re-translated and repeated in England as something quite new again; and what do they all amount to?

They have yielded 40 per cent. This is a very creditable result, and the engineers are to be much congratulated upon it, but they will admit it is a very poor figure when put beside the table shown in *Industries* in January, 1888, where, under the head, "commercial efficiencies," we find for certain tests: generators, 88·5 per cent.; motors, 90·30 per cent.; and total efficiency of transmission, 75·2 per cent. That is where the writer blames the electrician. They claim to have accomplished 75 per cent., and when they come to put it into actual practice they only reach 45 per cent. But now suppose they do realize even 45 per cent., are we justified in taking into coal mines wires which, if by any chance they are injured in their covering, will yield fire?

The ordinary condition of the main ways of our mines may be described as long dry passages, generally dusty and lined with timber. Falls occur, breaking down perhaps several yards of timbering. Wagons get off the road, knocking out the props, and upon those timbers we have to hang the wires, which can only be justly described as "fire conduits." A strong ventilation is passing, and often for considerable intervals no one could be present to see a fire beginning. We have for many years been doing all we can to prevent fire risks, either from shots or lamps. We are working on these lines, and now we are asked to introduce electricity! The danger seems too plain to require to be enforced by the large number of instances of fires the writer could quote arising from electric wires. Are we, then, to argue that this powerful medium is to have no place in the resources of engineering civilization? Certainly not. If the writer wished to convey power from, say the Quayside, at Newcastle, to Rothbury, amongst the hills, he would at once send for his electrical friends and take their advice and assistance. But we must remember that in London, where coals may be said to cost a full average of the price in England, they get a horse-power per hour for 0·15d. for coal, taking 1·65 lbs. of coal at 15s. per ton, which represents all the saving which can be made by means of utilizing what are called the forces of nature.

The following account is taken from the report of the Chief Inspector of Mines of the State of Ohio, and published in England at the end of last year:—

"The third installation of electricity during the year was at Mine No. 19, of Sunday Creek Coal Company. The power plant consists of a 110 horse-power engine and 100 horse-power dynamo. The electricity is conveyed along a 14 lb. T-rail at such a height as to allow persons and mules to pass under it safely. The motor car weighs 3½ tons, travelling over a road 717 yards long, which, at one point, reaches a gradient of 1½ inches per yard. The motor at its general work uses 29½ horse-power. It has supplanted in this mine 10 mules," which does not seem to be much to make a noise about. But we are told, in the inflated language of these

electrical puffs, "To the operator this haulage plant glitters with practical features." That is just where it seems to the writer to be deficient. An engine of 110 horse-power and a motor car of 3½ tons, with a rail overhead in the dusty coal mine, charged with a current of 440 volts, all to supplant ten mules, does not seem to glitter much, unless it is at the brushes of the dynamos; a motor car of 3½ tons getting off the road at a high speed and clearing out all the timber for 10 yards straight ahead, would be a practical feature more likely to promote strong language than, as is said, "to commend itself to the public on sight."

CONCLUSION.

Looking at our position, from a mining point of view, we seem to see that each system possesses features, which, whether they glitter or not, render them best under special conditions.

The use of hydraulic power, the pressure generated on the surface, and the pipes taking the water down, practically balancing the work of lifting it on its return, is one well worthy of adoption for all heavy work to be done in the neighbourhood of the shaft bottom.

For distances of about a mile, or say 2,000 yards, wire ropes, with careful attention to the fitting and maintenance of the bearing sheaves, will give results equal to any other mode of transmission; whilst for face work, beyond the caution-boards, compressed air, well cooled in the generating cylinder, still leaves all others, for absolute safety, far behind.

Electricity may suit for distant transmission on the surface, as in the case of the Niagara Cataract Construction Company, who are going to take 120,000 horse-power by means of a tunnel 1½ miles long, 490 square feet in section, on a slope of 7 feet to 10,000 feet, "and have settled," as they say, "on its form, predicated on the nature of the rocks through which it will be driven." They, no doubt, will be quite right in adopting this medium if the scheme is to have any success at all, but they must remember, that not only in this country where coals are cheap, but on the Continent, steam has gradually but surely supplanted both wind and water-mills—even the picturesque old windmills of Holland are disappearing.

The fact is, that where power upon the surface is required in what may be called bulk, no natural force can compete with a modern engine and boiler (where coals are available at an average rate) with any chance of success, especially if it involves the use of such a complication of machinery as turbines, dynamos, wires and motors. In a recent estimate by Professor Witz, of the cost of engine-power, made with a view to prove that a good gas engine can compete with steam, and therefore by no means too favourable to the latter, after a liberal allowance for first cost, interest and depreciation at 15 per cent. per annum, Cardiff coal at 21s. 10d., oil, grease, and wages, he makes the cost per actual horse-power on the brake not more than $\frac{5}{10}$ths of a penny per hour. If, however, the question is one of small quantities in workshops, as in Paris, then of course in such cases, there is a field for economical systems of transmission of power.

However, as a writer on a similar undertaking a short time ago said :—"This was to be used for driving engines in the town, and the place converted into a manufacturing city; but up to the present very few consumers have been found, showing that it is much easier to create motive power than a manufacturing industry for using the same."

The PRESIDENT hoped this paper would bring out an interesting discussion and that electricians would be sufficiently roused, on the subject upon which Mr. Steavenson had so severely criticized them, and reply particularly with regard to the power that could be utilized by the application of electricity.

Mr. HENRY LAWRENCE said that the subject was very interesting to him as he had for the last thirty-three or thirty-four years advocated the use of compressed air as a motive power for mining purposes, and they might remember some eighteen or twenty years ago, Mr. W. N. Taylor read a paper before the Institute; and a pair of compressing cylinders being erected at Ryhope Colliery, the then Mr. John Taylor asked him (Mr. Lawrence) how many underground engines this pair of 33-inch air cylinders would work. He replied that he thought about four. They commenced with a pair of 14-inch hauling engines, and he thought there were now four or five pairs working at various distances from one to two miles from the shaft underground. That seemed a large amount of work when they considered they were a pair of 32-inch steam cylinders, 5-feet stroke; the economy certainly verified everything Mr. Steavenson had said as to the power utilized. In ascertaining the utilized power of compressed air, mechanical engineers did not seem to be so well up in cooking the accounts as the electrical engineers appeared to be. The diagrams from the whole of the engines should be taken at the same time in making an ascertainment. There was frequently a very large amount of waste of compressed air, because the power is used intermittently, and sufficient care is not taken to prevent waste from the safety-valve; this tells of course against the motor in the shape of wasted coal. With respect to cooling the air, they had adopted the plan of placing a pump alongside the compressing cylinder, and working with the same stroke as the engines, to force the water in, in a very fine jet, as in France, and meeting the compressed air. Previously it used to be taken in at the suction side. A better result was obtained by a long stroke working simultaneously with the stroke of the compressor, rather than putting an eccentric on the shaft and only a small stroke to the injector. Freedom from wear in the cylinder could be obtained by using pure water and a self-acting lubricant.

The PRESIDENT said the discussion would be adjourned to another meeting. He was sure they would accord to Mr. Steavenson a hearty vote of thanks for the fund of information which he had given them in his paper.

This was carried with acclamation.

Mr. STEAVENSON acknowledged the compliment and said he was always glad to do what he could for the Institute. He had been a member now for thirty-six years, and as time was passing away they should all do what they could while life remained.

The meeting then concluded.

MEMOIR OF EDWARD FENWICK BOYD.

BY HIS SON, HUGH FENWICK BOYD.

EDWARD FENWICK BOYD, the subject of this memoir, was the third son of the late William Boyd, of Newcastle-upon-Tyne, a banker and a partner in the Newcastle Old Bank, of which the then Sir Matthew White Ridley was the head. He was born on the 30th day of August, 1810, at a house then occupied by my grandfather, the name of which was Egypt. My grandmother died young, in 1818, leaving my grandfather a young family to bring up, Edward being at that time only eight years old.

My father's earliest experiences of education were had at a day school kept by one Harry Atkinson in the High Bridge. In 1821 he was sent to a school, then of some note in the North of England, kept by the Rev. George Newby, rector of Witton-le-Wear, where he remained till July, 1826.

It was while he was at the Witton Grammar School that my father showed a taste for drawing. Some rough pencil sketches of his, drawn from nature, attracted the attention of Mr. Edward Swinburne, who persuaded my grandfather to send him to take lessons from the late Mr. T. M. Richardson, senior.

From August, 1826, to August, 1830, he "served his time"—first at Cocken White House, and afterwards, I believe, at Bowes' House with Mr. Thomas Crawford, then manager of Lord Durham's extensive collieries. Mr. Crawford was a viewer of the old school, and under him, undoubtedly, he learnt very thoroughly the practical part of his business, as it was then understood.

In 1830 my father went to Edinburgh University for the session commencing in October of that year, and here he stayed until the following May, attending lectures during two sessions of the University. After this all too short university training—all, however, that was deemed necessary at that time—he returned home to Ryton Grove, and, to use his own language, from May, 1831, to October, 1832, he was "an idle man at home." He kept his hand in during these years by going regularly down the Towneley Main Colliery, and in the latter year visited, in company with the late Mr. Matthias Dunn, various collieries in Scotland, at Preston Grange, near Edinburgh, and at Kilmarnock, Middleton, and Dalmellington in Ayrshire. It was probably through Mr. Dunn that he obtained his first appointment as underviewer and surveyor at the Hetton Colliery in 1832, the late Mr. John Robson being the resident viewer.

In 1837 he removed to Urpeth, as resident viewer of the Urpeth Colliery, then owned by Messrs. Bell, Morrison, & Co. It was in this year also that he obtained, mainly through the influence of Archdeacon Thorp, rector of Ryton, and an old friend of my grandfather, the appointment of mineral agent to the Dean and Chapter of Durham upon the retirement of Mr. T. Fenwick. This agency, which he held at

first under the Dean and Chapter of Durham, and afterwards under their successors, the Ecclesiastical Commissioners for England, until his death, gave him an unrivalled experience of the Durham coal-field.

At this time also he became manager of Wylam Colliery, on behalf of the Blackett family.

During the next twenty years, from 1837 to 1857, my father continued to live at Urpeth House. In 1841 he married Ann, daughter of Mr. George Anderson, of Newcastle-upon-Tyne.

The North of England Institute of Mining Engineers was founded in 1852. Many serious accidents in mines had taken place at or about that time, notably at Haswell in 1844 and at Seaton Colliery in 1852. The need was felt for some medium of intercommunication between mining engineers and those interested in pit management, with a view, if possible, of ascertaining their causes and preventing their recurrence. Out of this need, felt long before, but expressed apparently at first at the inquest which followed upon the accident at Seaton Colliery,* sprang the Northern Mining Institute. My father lent all the assistance in his power to its formation and advancement, was a constant and assiduous attendant at its meetings, and served the office of Treasurer from its foundation until 1869, when he was elected President upon the resignation of Sir George Elliot.†

In 1855 my grandfather died, leaving behind him a moderate fortune, of which my father had his share. The bulk, however, was held in shares of the Northumberland and Durham District Bank, which, during the mania for joint stock banks in 1845, had replaced the old firm of Sir Matthew White Ridley & Company. In 1856 my father bought the property at Moor House, where he afterwards resided, built himself a house, resigned his position as manager of Urpeth Colliery, and was proposing to take life somewhat more easily. Then came the financial crisis of 1857, and the District Bank went down. Those were days before the companies' statutes had permitted a shareholder to limit his liability, and the calls upon the shares which my father held in the bank engulphed not only the fortune which he had inherited from my grandfather, but his private savings also, and he saw himself at the age of forty-seven with a young family to educate and his fortunes to begin afresh. Such a prospect might have daunted a less buoyant nature. It only nerved him to fresh exertions. He kept on his old and took on new agencies, and the years from 1857 to 1872 were among the busiest and fullest of his full and busy life.

* See the inaugural address of Sir George Elliot, Transactions, vol. xviii., p. 20. The inquest took place upon the 23rd June, 1852. A meeting of colliery owners and viewers was held at the Coal Trade Offices upon the 3rd of July (vol. i., p. 5), at which a committee was appointed to report. The committee reported at a subsequent meeting upon the 21st of August, and officers were appointed and the Institute sprang into full being upon the same day.

† He contributed to the Institute the following papers:—

(1) "On a Part of the Carboniferous or Mountain Limestone Series of North Northumberland."—Transactions, vol. ix., page 186.

(2) In conjunction with Mr. Nicholas Wood, "On a Wash or Drift through a portion of the Coal-field of Durham."—Transactions, vol. xiii., p. 69.

(3) "Remarks on the Coal-Measures and Oil Produce of the United States of America."—Transactions, vol. xxv., p. 145.

(4) He had a large manuscript collection of sections of the various strata through which pits in different parts of the counties of Durham and Northumberland were sunk. Some of these were published by the Mining Institute separately from the Transactions.

In 1858 my father became the chief mining engineer to the Consett Iron Company, and until 1872 he directly superintended the working of their various collieries. In 1872 he relinquished the more active management into the hands of his friend and former assistant, Mr. W. H. Hedley, but continued his connexion with the company, as consulting engineer, until August, 1887.

Upon the 7th of August, 1869.* my father was elected President of the Institute, this public recognition of his services gave him the most unaffected pride and pleasure.

Two principal events distinguished his term of office, the foundation and affiliation with Durham University of the Physical Science College, and the opening of the Wood Memorial Hall.

The project of a Physical Science College for Newcastle was of old standing. It engaged the earnest attention and anxious thought of the first founders of the Institute. It is referred to in more than one of Mr. Nicholas Wood's annual addresses to the Institute, and my father's diary for 1855 shows that he was in communication with Mr. Wood upon the subject in that year.

It was felt that to affiliate the Mining College with Durham University would give it a prestige that it would not otherwise possess. And on the other hand it might not be improper, nor in disaccord with the intentions of the founders of that University, if some portion of its revenues were diverted for the endowment of professorships of chemistry, geology, mining, and mathematics, subjects which bore specially upon the training of those who had to manage the staple industries of the district. My father very shortly after the foundation of the Institute acted as intermediary between the Institute and Archdeacon Thorp, then Warden of the University, with a view to obtaining his co-operation towards the furtherance of these objects. But the project at that time, for various reasons, which it is not necessary to recapitulate, fell through. Through years of discouragement my father clung to the idea with characteristic pertinacity, and endeavoured to inoculate others with the same enthusiasm. At last, in 1870, his opportunity came, and he promptly seized it. There was at that time a conjuncture of favourable circumstances. The trade of the district was in a flourishing condition. There was a strong and well-sustained demand for young men of ability and energy to manage the industries of the district. The need for a more thorough scientific training was self-evident; and the present Dean of Durham, whose reputation had preceded him, was installed as Warden of the University. The time seemed ripe for a new departure. Very shortly after his arrival in Durham my father called upon Dean Lake, and laid the whole case before him. The Dean listened favourably, and asked for further confirmation of his views. This was supplied by Sir Isaac Lowthian Bell, who had come into the plan warmly, and whose high scientific attainments well qualified him to give assurance on the subject. The Dean writes:—"It was owing to their advice that it was determined to found the College at Newcastle, and

* Transactions, vol. xviii., p. 153. His Inaugural Address as President was delivered upon the 6th of November, 1869. Transactions, vol. xix., p. 41.

not, as some wished, at Durham; and it was by their support and encouragement that a large sum of between £30,000 and £40,000 was collected, which, in addition to the annual subvention from this University, was the means of founding the College." The movement gathered impetus as it went. If I may judge from the entries in my father's diary, the subject was hardly ever absent from his thoughts from the autumn of 1869 until the matter was completed in 1871. On the 9th of November, 1869, a committee was formally appointed by the Mining Institute to confer with the Principals of Durham University. Many private conferences took place in 1870 between the Dean of Durham, my father, Sir Isaac Lowthian Bell, and others interested in the movement, at which the basis of agreement was settled. Upon the 11th of March, 1871, the matter was ripe for public discussion, and a meeting was held in Newcastle, before which my father laid the proposals of the Dean. Upon the 25th of March, 1871, another public meeting in continuation took place, at which the Dean, who was present, further developed his proposals, some of which had been criticised at the previous meeting. They were then unanimously adopted, and subscriptions to a large amount upon the suggestion of Mr. Joseph Cowen were promised in the room. The matter then proceeded rapidly and smoothly, and the constitution of the College was passed upon the 10th of June, 1871.* For the smooth and successful working out of the details, the College owes a deep debt of gratitude to the late Mr. T. W. Bunning. For many years my father was hardly ever absent from the Council meetings of the College, he always took the warmest interest in its welfare, and looked forward eagerly to the erection of such a building as the College now possesses. My father, to his great regret, was not able, owing to ill-health (he had had a slight threatening of paralysis in the spring of that year), to attend the ceremony when the foundation stone of the new buildings was laid upon the 15th of June, 1887. His views as to the proper aims and aspirations of the College, and as to the best means in his opinion of attaining success, are contained in two letters which he published in the Newcastle journals.†

It is hardly necessary to do more than refer to the opening of the Wood Memorial Hall in the summer of 1872, upon which occasion my father as President delivered an address.‡ It gave a local habitation to the mining body, and besides doing honour to their first President, evidenced the full growth of an Institution over whose infancy Mr. Wood had watched with loving care. My father's health at that time was the subject of grave anxiety to his family and friends, but, after a successful and skilful operation at the hands of Sir James Paget, for many years afterwards he enjoyed his wonted health and vigour.

In 1875, my brother, Robert Fenwick Boyd, joined my father as partner, and from that time forward took from off his shoulders all the heavier part of his work. In

* See the following references, where further information upon this subject will be found:—*Times* (leading article), 9th November, 1869; *Times*, 12th November, 1869 (letter from the Dean of Durham in reply); *Newcastle Daily Chronicle*, 13th and 27th March, 1871 (accounts of the public meetings); *Durham County Advertiser*, 12th November, 1869, and 31st March and 12th May, 1871; *Times*, 12th April, 1871 (leading article).

† *Newcastle Daily Chronicle*, October 13th, 1885, and *Newcastle Daily Journal*, in June or July, 1887.

‡ Transactions, vol. xxi., p. 223.

this year also he visited for the first and only time in his life the United States, and there gathered the materials for a paper upon "The Coal-Measures and Oil Produce of the United States of America,"* which was the last he read before the Institute.

About this time he was made a magistrate for the county, and henceforward devoted a good deal of his time, while health remained, to the administration of the law and to county business. He brought to the exercise of his new functions the same pervading sense of duty which was the keynote of his life; and served usefully and energetically upon many of the committees through which the business of the county was principally conducted.

My father's health began visibly to fail in 1883.

I was absent from England for about two years at that time without seeing him, and upon my return in the summer of 1884 the change was very marked. From a young man he had become suddenly an old. Old age which makes others talkative seemed to impose silence upon him, and it was very sad to see one who had been the merriest and brightest of the family circle sit silently and abstractedly in the place where formerly his sallies and his stories had been wont to "set the table on a roar." Yet I do not think he was unhappy, and he was carefully watched and tenderly cared for by a much loved daughter, who had since my mother's death in 1861 taken, so far as it was possible for anyone to take, her place beside him. It is pleasant, too, to think that his powers of mind never failed him and that he was able to take much interest in his garden, in his books, and above all in his beloved painting, down to within four days of his death.

And so the end came upon the 31st of August, 1889, quietly and peacefully, though somewhat suddenly at the last.

* Transactions, vol. xxv., p. 145.

CHESTERFIELD AND MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

GENERAL MEETING,

HELD AT THE ROYAL VICTORIA HOTEL, SHEFFIELD, APRIL 11TH, 1891.

MR. JOHN JACKSON, PRESIDENT, IN THE CHAIR.

The PRESIDENT said there was very little before them as a separate Institution, but later that day they were to hold a joint meeting with the Midland Institute, when there would be papers to discuss and other business to transact. He thought that the joint meeting was likely to be very successful, as in the visit to the Nunnery Colliery that morning there had been a goodly muster of members of both Institutes, and every arrangement had been made for the day's proceedings throughout being pleasant and profitable.

The SECRETARY said the following gentlemen had been found duly elected by ballot:—

MEMBERS—

Mr. George William Dickinson, Colliery Manager, Clay Cross.

Mr. Percival John Fenwick, Surveyor and Colliery Manager's Assistant, New Hucknall Colliery, near Mansfield.

The PRESIDENT, proceeding, said on the agenda paper the next business was for particulars of any proposed alterations of rules or bye-laws to be given. The Council had nothing to propose, nor did they desire to alter anything, but it was open to any members of the Institution now to give notice of such proposals, which would be considered at the annual meeting.

There was no response.

The PRESIDENT said candidates for election as officers of the Institution for the ensuing year must now be nominated. He had very great pleasure in announcing that the Council had unanimously invited Mr. J. A. Longden to take the office of President, and that Mr. Longden had consented if it should be the wish of the meeting also. The nomination was unanimously accepted.

Nominations for ballot for Vice-Presidents and Councillors suggested by the Council and added to by the meeting were approved as follows:—Vice-Presidents eligible for re-election and in addition, Messrs. W. E. Wells, S. Alsop, and H. Walters. Councillors eligible for re-election and in addition, Messrs. W. Spencer, J. W. Fearn, W. Salmond, J. C. B. Hendy, G. Fowler, and W. Davies.

Notice was given on behalf of the Council that the question of the continuance of this Institution in the Federated Institution would be considered and determined on at the annual meeting; also that in the event of continuance, the present representatives be re-elected.

The PRESIDENT announced that a paper by Mr. J. Bagnold Smith, "On Colliery Depreciation," was taken as read, and would be printed with the proceedings of this meeting.

Mr. W. SPENCER and Mr. W. SALMOND proposed and seconded a vote of thanks to the President, congratulating him on his recovery from injury by accident.

Mr. JACKSON acknowledged the vote, and the meeting ended.

ON COLLIERY DEPRECIATION.

By J. Bagnold Smith, F.R.A.S.

This is a subject which has usually been dealt with simply from an accountant's point of view. The problem divides itself into two classes at the outset, both of which can be, however, dealt with on the same lines.

The chief factors are—first, the capital invested; next, the time of lease; and, thirdly, the area of the coal-field.

It is plain that the farther workings extend from the shaft the greater the length of roadway to be maintained. This is a considerable item of expense, and a growing one.

Hence this consideration gives the following main principle:—That as the colliery extends in area and distance so the expenses of working increase to some extent, and that hence a ton of coal near to the shaft bottom can stand more for depreciation than a ton at the far end of the coal-field. So at compound interest which must be taken in calculating all annuities, the larger depreciation at the commencement would accumulate by interest a larger sum than if taken for a smaller term of years.

A usual way to take the problem is this:—What sum must be put by yearly at interest to produce, allowing for the value of the plant at the end of the term, the original capital?

Another way is to say to an insurance company:—What sum must I pay you yearly for so many years in order that you may hand me over at the end of the term a sum of money equal to my original capital?

This is given easily from the ordinary formulæ for annuities.

Taking the fact that the yardage of roadway to be maintained annually increases, and that provided the thickness and quantity raised be similar per year, we may assume that the yardage of roadway approximately varies as the number of years worked.

The approximate statement is, the length is equal to the yardage driven in the first five years + the number of main roads and main gates multiplied by the number of years multiplied by the average annual rate of face progress. Or, if N be the yards of roadway, C the amount at the end of five years, R the number of main gates, and r the annual rate of face progress, and K a constant dependent on the mode of work and cutting off, then

$$N = C + KRrn \text{ when } n \text{ is the adult age of the colliery.}$$

This shows us that if n be the number of years of the lease, and a the last payment, and that five years be allowed at no depreciation to get the pit into full work,

the following sums would be paid :—a, $2a$, $3a$, $4a$, ... $(n-5)a$. The last payment (a) will be paid a year before the lease expires, and the next two years, and the first $(n-5)$ years, which are the terms at interest of which ρ is the amount which £1 will produce in one year at the given rate.

Hence to obtain our last term from which all the others are derived we have the following series, of which Σ the amount to be recouped is the sum :—

$$\Sigma = a\rho + 2a\rho^2 + 3a\rho^3 + 4a\rho^4 + \ldots\ldots\ldots + (n-5)\rho^{n-5},$$

where Σ, ρ and $(n-5)$, which we will denote by n, are respectively Σ the capital to be recouped, ρ the amount of £1 for one year at the given rate of interest, and n the number of years of the recouping operation. Hence we have to find an expression for the sum of the series to n terms.

$$\Sigma = a\rho + 2a\rho^2 + 3a\rho^3 + \ldots\ldots + (n-1)a\rho^{n-1} + na\rho^n,$$

we obtain as the value of the series to n terms,

$$\Sigma = \frac{a\rho^{n+1}\left[n(\rho-1)-1\right] + a\rho}{(\rho-1)^2}.$$

From this the last payment a is obtained, and is—

$$a = \frac{\Sigma\,(\rho-1)^2}{\rho^{n+1}\left[n(\rho-1)-1\right]+\rho}.$$

The result of this process will be best seen by an example :—

Let the capital of a colliery be £100,000, the term of the lease be 55 years, and the rate of interest allowed be—say 2 per cent. or 3 per cent.

Here the term over which the depreciation is carried is 50 years. We obtain results as under :—

	2 per Cent. £ s. d.	3 per Cent. £ s. d.
Last payment	39 4 3	27 7 6
First payment	1,960 12 6	1,368 15 0

In negotiating an arrangement of this kind with a financial company, protection would have to be obtained against several eventualities :—

(a) The voiding of the lease under either optional or other clauses.

(b) Bankruptcy of colliery company, and consequent stoppage of working.

(c) Stoppage of pit from unforeseen causes.

Many methods of depreciation are in use, of which some are so constituted as to become more onerous as the pit increases in age. Others provide an annual depreciation, regulated by the acreage worked each year, in which the benefit of interest accruing is lost.

(a) By fixed annuity. In answer to the question—What sum of money must be paid per annum, for 50 years, to produce £100,000 at the end of the term, calculating interest at 2 and 3 per cent. respectively?

We obtain annuity at 2 per cent., £1,182 6s. 2½d.

„ „ 3 „ £886 11s. 0d.

(b) Regulated by the acreage.

In this example we obtain $\frac{100000}{1500}$ = £40 as the charge on each acre of coal, and assuming 5,000 tons to the acre, we obtain a fixed depreciation charge of 1·92d. The table gives us an idea how the three methods affect the cost during the first ten years of the colliery's adult life, and during the last ten years of its old age.

It will be seen from the table that by the method proposed the charges become lighter as the pit grows older, by the fixed annuity method they are least when the pit is in its prime of life, and constant during the whole life under the acreage system. In this system it is not usual to make deductions for pillars and faulty coal, and consequently the total cash sum paid never quite reaches the original capital, nor does interest on payments go to lighten the charge. The method outlined in this paper is an attempt to combine an actuary's with a mining engineer's view of the problem.

The heaviest payments come at a time when the plant and machinery should be in the best order and need small expenses for repairs. As the pit grows older, and the expenses of upkeep of machinery and plant increase, the depreciation charge has been, by the operation of this process, much lightened, and the charges are more easily borne.

It is brought forward, not as a perfect scheme, but as giving some results obtained from a careful study of the question, which has, at several periods, engaged the writer's attention.

CAPITAL, £100,000. TERM OF LEASE, 55 YEARS. ACREAGE LEASED, 2,500. THICKNESS OF SEAM, 4 FEET. TERM OF RECOUPING OPERATION, 50 YEARS. INTEREST CALCULATED AT 2 PER CENT. AND 3 PER CENT.

Year.	Assumed Output.	Graduated Annuity.				Constant Annuity.				Acreage Depreciation.		
		Payment, 2 % basis.	Cost per Ton.	Payment, 3 % basis.	Cost per Ton.	Payment, 2 % basis.	Cost per Ton.	Payment, 3 % basis.	Cost per Ton.	Acreage.	Depreciation.	Cost per Ton.
		£ s. d.		£ s. d.		£ s. d.		£ s. d.			£	
6	150,000	1,960 12 6	3·14	1,368 15 0	2·19	1,182 6 2½	1·89	886 11 0	1·42	30	1,200	1·92
7	160,000	1,921 8 3	2·88	1,341 7 6	2·01	"	1·77	"	1·33	32	1,280	"
8	170,000	1,882 4 0	2·65	1,314 0 0	1·85	"	1·66	"	1·25	34	1,360	"
9	180,000	1,842 19 9	2·45	1,286 12 6	1·72	"	1·57	"	1·18	36	1,440	"
10	190,000	1,803 15 6	2·27	1,259 5 0	1·59	"	1·49	"	1·12	38	1,520	"
11	200,000	1,764 11 3	2·12	1,231 17 6	1·48	"	1·41	"	1·06	40	1,600	"
12	210,000	1,725 7 0	1·97	1,204 10 0	1·38	"	1·35	"	1·01	42	1,680	"
13	220,000	1,686 2 9	1·83	1,177 2 6	1·28	"	1·29	"	0·97	44	1,760	"
14	230,000	1,646 18 6	1·72	1,149 15 0	1·20	"	1·23	"	0·93	46	1,840	"
15	240,000	1,607 14 3	1·61	1,122 7 6	1·12	"	1·18	"	0·89	48	1,920	"
45	250,000	431 6 9	0·41	301 2 6	0·29	"	1·13	"	0·85	50	2,000	"
46	230,000	392 2 6	0·41	273 15 0	0·29	"	1·23	"	0·93	46	1,840	"
47	210,000	352 18 3	0·40	246 7 6	0·28	"	1·35	"	1·01	42	1,680	"
48	190,000	313 14 0	0·39	219 0 0	0·28	"	1·49	"	1·12	38	1,520	"
49	160,000	274 9 9	0·41	191 12 6	0·29	"	1·77	"	1·33	32	1,280	"
50	130,000	235 5 6	0·43	164 5 0	0·30	"	2·18	"	1·64	26	1,040	"
51	100,000	196 1 3	0·47	136 17 6	0·33	"	2·84	"	2·13	20	800	"
52	70,000	156 17 0	0·54	109 10 0	0·38	"	4·05	"	3·04	14	560	"
53	50,000	117 12 9	0·56	82 2 6	0·39	"	5·67	"	4·25	10	400	"
54	50,000	78 8 6	0·38	54 15 0	0·26	"	5·67	"	4·25	10	400	"
55	50,000	39 4 3	0·19	27 7 6	0·13	"	5·67	"	4·25	10	400	"

The following new members were found duly elected by ballot at the previous meeting, January 10th, 1891, and were so declared at that meeting :—

MEMBERS—

Mr. George Jonathan Binns, F.G.S., Agent and Manager, Netherseal Colliery, Burton-on-Trent.

Mr. Oscar Joseph Cotterell, Manager, North Staveley Colliery, 16, Bank Street, Sheffield.

Mr. John Henry Day, Manager, Butterley Co.'s Stone Quarries and Lime Works, Bull Bridge, Ambergate, Derbyshire.

Mr. Leonard Calvert Gillett, Mining Engineer, Osmaston Road, Derby.

Mr. John Plowright Houfton, Colliery Manager, Bolsover.

Mr. Edward Ferdinand Melly, Colliery Manager, Griff Colliery, Nuneaton.

STUDENTS—

Mr. William Eames, Colliery Surveyor, Netherseal Colliery, Burton-on-Trent.

Mr. Warden Appleby Moller, Mining Engineer, Penny Pie Hall, Old Radford, Nottingham.

MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS,

AND

CHESTERFIELD AND MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

JOINT MEETING,

HELD AT THE ROYAL VICTORIA HOTEL, SHEFFIELD, APRIL 11TH, 1891.

MR. JOSEPH MITCHELL, M. INST. C.E., F.G.S., PRESIDENT OF THE MIDLAND INSTITUTE IN THE CHAIR.

VISIT TO THE NUNNERY COLLIERY, SHEFFIELD.*

The CHAIRMAN—I would first of all propose that the best thanks of the members of the Chesterfield and Midland Institutes be given to the Nunnery Colliery Company, and especially to Mr. Emerson Bainbridge, who has been at so much trouble, and has kindly imparted some very useful information. As we have in our hands printed particulars of what we were to see, and have made our visit, Mr. Bainbridge, I am assured, will be very pleased to answer any questions that members may wish to ask. Meanwhile I have great pleasure in proposing that our best thanks be given to Mr. Bainbridge for the trouble he has taken.

Mr. JACKSON (President of the Chesterfield Institute)—I have great pleasure in recording on behalf of the Chesterfield engineers that we were much interested in everything we saw at the Nunnery Colliery, and as we are in a comparatively new district I hope some of our members may have seen something that it will be interesting to them to ask Mr. Bainbridge more questions upon. There is a great variety of machinery, and the plant is of a very substantial character.

The resolution was carried unanimously.

Mr. E. BAINBRIDGE said that as no questions were asked he took the opportunity of acknowledging the kind vote of thanks. It was possible that the information given on the slip handed to members that morning was sufficient to enable them to dispense with any further questions, but if anything should arise on which more information was wanted, he would be pleased at a future meeting, or by correspondence, to give it. It had been an especial pleasure to himself to have been the means of showing the party that day over the Nunnery Collieries, since he believed it was the first time the two Institutes had joined together for discussion. He hoped it would be the first of a series of useful meetings at which members might combine together for the purpose of discussing matters of mutual importance.

* See description on page 237.

DISCUSSION UPON MR. MAURICE DEACON'S PAPER ON "COMPARATIVE EXPERIMENTS UPON A CAPELL AND A SCHIELE FAN WORKING UNDER SIMILAR CONDITIONS."

The CHAIRMAN—We will now take the discussion on Mr. Deacon's paper. Possibly he may have something to add before the discussion commences.

Mr. DEACON had no additional remark to make, but would be glad to answer any questions.

Mr. J. CRIGHTON wished to ask some questions. He thought it was well understood that in experiments upon fans on pits, the water-gauge should be taken in the fan drift. He believed that was finally settled by the North of England Institute some years ago, and that being so, he could not admit the statements made here to be right. In one case the Schiele fan appeared to have produced 43,699 cubic feet of air per minute with a water-gauge of 1 inch in the fan drift, and ·45 down below at the separation doors; and in the next the Capell fan produced under the same conditions and on the same pit 60,084 cubic feet of air per minute with a water-gauge of 1 inch in the fan drift and ·7 below. How could that be, as it was impossible to get that volume and keep the water-gauges the same if the latter were taken properly in the fan drift. In the next case, the Capell increased from 60,084 to 118,241 cubic feet, with a water-gauge of 3·25 in the fan drift and 1·8 in the pit. He (Mr. Crighton) said this could not be correct, for to increase to 118,000 there must be 2·7 water-gauge down below. The Schiele fan, tested under so-called similar conditions with the Capell—but the conditions were not similar—was a fan for 30,000 feet of air per minute, with a 3-inch water-gauge. It was like putting a child to do as much work as a man. It was impossible for that little fan to pass anything at all approaching the amount of air which the large Capell fan should pass. The only way to work under similar conditions would be to have fans of the same size, driven by engines of equal power, with a fan drift and every other condition similar, to take the water-gauge down below, and then to measure the air down below in the returns and close to the bottom of the upcast. Under these conditions he offered on behalf of the Schiele to arrange for a good test with the Capell anywhere; but with such conditions as those referred to in the paper, he could do nothing, because they were absurd. For one thing, the dissimilar conditions would force the Schiele to show a water-gauge of 4 inches to produce 1¼ inches in the pit, whereas the Capell, with a water-gauge of 3·25 inches, produced 1·8 inches in the pit, and used its high water-gauge for its useful effect. The correct place to take the water-gauge was at the top of the upcast opposite the fan drift. His own deduction was that Mr. Capell got 37 per cent. of useful effect with his large fan on that pit, and not 69 per cent.

Professor LUPTON referred to a paper he had read before the Midland Institute in December, 1889, on a fan he had designed and designated "The Medium Fan" (see *Transactions of the Federated Institution of Mining Engineers*, pages 65–72, Vol. I.). Having communicated with the President and Secretary of the Midland Institute, he understood that he should be in order in coupling with remarks on Mr. Deacon's paper some observations upon his own, the discussion on which had not been closed. The Medium fan that had been constructed from his designs was 20 feet diameter, and was put up to give 40,000 cubic feet of air per minute; actually it was producing 60,000 feet. In observing such fans as those of Mr. Capell and Mr. Schiele, he had considered that the entrance orifice was restricted, causing an appearance of high water-gauge in the drift immediately adjoining the fan, which high water-gauge was not actually realized in the pit. Therefore he made the entrance to the Medium fan of such a size that there should be no constriction of air either in the entrance or discharge from the fan, to cause undue friction, and to raise the water-gauge unduly. Mr. Deacon's paper was one of the most useful and instructive papers ever put before the Institute. He would venture to suggest that it was sometimes difficult to make accurate experiments, even with the best intentions, and he thought this paper showed that difficulty. The preceding speaker said some of the results obtained were impossible. He (Professor Lupton) did not agree with him there. He did not think they were perfectly theoretically consistent one with another, but that was the case with all experiments which were not cooked. The fact that they were inconsistent showed that they were given by an engineer who recorded what he had found, and left inconsistencies open for criticism. Having said that, he should like to point out that the water-gauge, as indicated at the fan drift and the doors at the bottom, showed a remarkable amount of shaft friction, to say the least of it. He had calculated what the shaft friction should be for the depths and size given, and allowing for a considerable length of roadway, he estimated the shaft friction at a maximum, with the air going at 120,000 feet per minute, at about ·66 or two-thirds of an inch water-gauge. If, in the case of the volume of 122,012 feet of air, with two inches of water-gauge at the separation doors at the pit bottom, ·66 were added, the theoretical water-gauge in the fan drift became 2·66 inches, instead of 3·85 inches as given in the paper. What had become of the difference? No doubt when Mr. Deacon replied it might be accounted for. But supposing it could not be accounted for except on the theory that the constriction of the fan orifice gave an apparent water-gauge at the fan which did not exist in the mine, the effective work would be reduced by one-third. The efficiency, instead of being 74 per cent., would be reduced to about 50 per cent; for substituting ·66 shaft friction for 1·85, the efficiency was brought down to 50 per cent., which was a very good efficiency. No mine owner would complain of that percentage efficiency, but he thought if the air-way in the fan were enlarged, there would be a larger efficiency. With regard to the Schiele fan, there could be no doubt that the air was knocked about somewhat unduly; and

whether it were called re-entry or otherwise described, there was doubtless a certain amount of power wasted. The Schiele fan as a rule had a restricted entrance, causing loss of power in the fan, in a similar way to what happens in the Capell fan (with the result in the case of the Capell fan that the fan water-gauge was so much higher than the water-gauge at the separation doors). But the Capell fan water-gauge at the highest was not a high water-gauge. Taking the speed of the periphery of the fan, and calculating the theoretical water-gauge, it would be found that the actual water-gauge was 10 per cent. less than the theoretical water-guage. In the Guibal fan, which Mr. Robert Howe had so thoroughly described, the actual water-gauge was from 20 per cent. to 30 per cent. higher than the theoretical water-gauge, according to the way in which it was worked, and according to the quantity of air passing through. He did not mention that as necessarily giving high useful effect, but as giving a high water-gauge. There might, however, be a high useful effect with a low water-gauge, and *vice versâ*.

Mr. G. M. CAPELL wished to disclaim having anything to do with these comparative experiments with the Capell and Schiele fans. They were made, and after they were made he heard of them, but had absolutely nothing to do with them more than seeing the results after they were taken. Mr. Deacon would corroborate that statement. Professor Lupton had remarked that the entrance to the Capell fan was restricted. The Capell fan was 12 feet 6 inches diameter, and the inlet 7 feet 6 inches. Would Professor Lupton state the size of the inlet of his 20-feet fan?

Professor LUPTON—7 feet.

Mr. G. M. CAPELL—If the Capell fan inlet was 7 feet 6 inches to a 12 feet 6 inch fan, against 7 feet to a 20 feet Medium fan, he considered the former inlet had much less restriction. He prided himself that the Capell fan had no restriction of inlet or exit. The air passed through the port-holes in the cylinder, which were carefully regulated and larger than the size of the inlet. As Mr. Herbst, engineering professor of the Mining School of Bochum had said, "There is no restriction in the Capell fan, though at first sight it might appear so to those who have not studied the question, the port-holes in the cylinder being larger in area than the inlet." That, he (Mr. Capell) considered, was the reason why the Capell fan was able to pass larger volumes of air, at high gauge, than any fan of the same size with which he had hitherto been acquainted. In this opinion he was entirely corroborated by experiments made in Germany, where he had a fan 12 feet 6 inches in diameter; and where, he might be allowed to add, he should shortly have two more running, which were to give 127,000 cubic feet on test, and 10·70 inches water-gauge. That did not look as if restriction at the inlet of the Capell fan had any material effect. Gauges in Germany were taken a long way off in the passages of the mine, more than 100 feet from the exit of the fan. He agreed that the question where the gauge should be put required careful consideration. He understood that the gauges in the recent experiments, made by the Fan Commission in England, had been taken 6 feet from

the entrance to the fan inlet. In Germany it was not so, and there the gauge tube was placed at right angles to the air-current. In the five experiments made by Mr. Herbst, reporting engineer of the Prussian Fire-damp Commission, and professor of engineering at the Bochum Mining School, he insisted on having the gauge pipe ground up to knife edge, in order to prevent any air eddying round the pipe edge, and so interfering with the water-gauge. As to the theoretical gauge, Mr. Lupton used $h = V^2 \div 2g$ or $V^2 \div 64{\cdot}4$, h representing the height of the column of air which was raised by the centrifugal force or velocity of the blade tips of the fan.* This formula had been abandoned on the Continent, in France, Belgium, and Germany. It was not $h = V^2 \div 2g$ but $h = V^2 \div g$, and the theoretical gauge was now double what was formerly used.† All the gauges stated to-day had been worked on the double theoretical gauge and not on the single theoretical gauge. The proportion of actual to theoretical had been calculated on double the amount of theoretical gauge to which Mr. Lupton alluded. With regard to the gauge on a mine being invariable (the quantity of air that could be passed at a given gauge on the mine being invariably the same with every fan) he had stated five years ago his conviction, from experiments, that such was not the case; that fans had local power of creating gauge, and that the local power of creating gauge was different in different fans, and some fans had the power of throwing their gauge farther back into the mine than others. About that he had not the smallest possible doubt, from experience, with many fans in Germany, Capell and Guibal fans, working side by side, and certain results before the meeting to-day. That conclusion was further corroborated by Mr. Longden's statement, that on his own fan he found the same thing, namely, an entire discrepancy between the observed gauge required at the fan drift, to get the same quantity of air as had been previously got by the furnace. On such an occasion as this it could not be out of place to go back some years on this subject. In 1884, being then very young in the matter of fan experiments, he succeeded in getting a trial in a colliery at Cradley, between a very small open fan, made for mine experiments, and a 16-feet Guibal fan. It was at Homer Hill Colliery—the results were published, and the writers in the *Colliery Guardian* plainly said it was nonsense. The observations were taken by Mr. J. E. Swindell, and recorded in his (Mr. Swindell's) book. The mine was blocked to bring its capacity somewhere near that of the small fan. At 1-inch gauge the Capell fan passed 14,128 cubic feet of air; the Guibal at 1¼-inch 14,508 feet of air. The Guibal fan, at 1-inch water-gauge, passed 11,412 feet, so that practically the Guibal fan took 1¼-inch gauge to do what the little Capell fan did at 1-inch gauge. At Tamworth Colliery a Capell fan had now been working several years. It was constructed to meet the state of things in that pit. The furnace gave 10,125 feet of air with ·75 inch water-gauge. The Capell fan was then put on the pit, the air and water-gauge were taken at the same place, and Mr Ridsdale stated

* To reduce this to inches of water-gauge multiply by 0·0012 × 12.

† The fans can only show a percentage of the new theoretical gauge which they can never reach.

that the fan gave 10,600 cubic feet with ·30 inch water-gauge, immediately after it had started work. In Germany a 41-feet Guibal fan was in use at a colliery near Dortmund. It gave 1,700 cubic metres of air; water-gauge, 40 millimetres. A Capell fan, 11 feet diameter, was put on that mine by the same makers as the Guibal fan, and the quantity it gave was 3,147 cubic metres, with 76 millimetres gauge, as against the 1,700 cubic metres by the Guibal with 40 millimetres depression. That was to say, the Guibal fan took 40 millimetres depression to get 1,700 cubic metres, and the Capell took 76 to get 3,147. There was no theoretical connexion between these figures, which were stated by the manager at a large meeting of engineers, then comparing the two fans, at this splendid colliery. There was another colliery, Berge Borbeck, near Essen, the facts respecting which were stated by Mr. Herbst, of Bochum. A 41-feet Guibal fan, tested on the mine, gave 1,600 metres, with 80 millimetres depression. A Capell fan, 12 feet 6 inches diameter, was put down, and gave 3,614 cubic metres of air, with 270 millimetres depression; that was, 10·70 inches water-gauge. The Guibal fan would have required 405 millimetres depression, or about 16 inches water-gauge to have given 3,614 cubic metres of air, and the horse-power in the air would have been 324, instead of as actually by the Capell fan (with 270 millimetres depression) 217 horse-power in the air. It was possible some leakage took place, but this would be common to each fan, and would not account for the discrepancy. In the calculation of the Guibal fan results a heavy leakage takes place, for he (Mr. Capell) found on looking to the original enquiry, that it was estimated that 3,000 cubic metres in the fan drift would only produce 2,500 cubic metres below ground. His calculation was that the 12½-feet Capell fan would give 3,300 metres at 11 inches water-gauge, but in the result 3,614 metres were turned out with 10·70 inches water-gauge. He had another similar case of a Guibal fan and a Capell fan in England, but had not yet got independent measurements of results. These discrepancies between the Guibal and Capell fans had been observed in this matter of gauges. He considered it a subject for scientific investigation, for his experience led him to suspect, as he had said at first, that some fans had a strong local action in their gauge, which did not extend so far as others into the mine. Mr. Deacon's experiments showed this principle; but other experiments, which he hoped might be made, would in time enable results to be accurately calculated before hand.*

The CHAIRMAN—We may take it this is an addition to Mr. Deacon's paper?

Mr. CAPELL—I consider it is bearing on the question of gauge, which is the main point in Mr. Deacon's paper.

The CHAIRMAN—But you appear to be reading from printed matter?

Mr. CAPELL—No: from a few written notes. Compare the first experi-

* Since this meeting a similar discrepancy of gauge was found at the Grand Hornu Colliery in Belgium. A 12½-feet single inlet Capell fan replaced two Lemielle ventilators. The Lemielle on No. 8 pit, with the other Lemielle standing, gave 22 cubic metres of air at 50 millimetres of water-gauge. The following results were given by the Capell fan:—Depression 40 millimetres, 31·6 cubic metres per second; depression 100 millimetres, 57·7 cubic metres; and depression 260 millimetres, 75·0 cubic metres.

ments with a Capell fan in the case where that fan gave at 1-inch gauge 14,128 cubic feet, the Capell fan produced practically the same amount of air as the Guibal, and took 66 per cent. of the Guibal guage for 14,508. At Prosper Colliery, in Germany, to produce 3,614 cubic metres, the Capell fan took 270 millimetres = 10·7 inches water-gauge. The Guibal fan would have taken 405 millimetres, or nearly 16 inches water-guage. This, it would be found, showed about the same percentage, viz., the 270 millimetres of the Capell fan was 66 per cent. of the Guibal gauge. It was a curious circumstance that such coincident figures should come from such widely different quarters and conditions of working. He always tried to avoid giving observations made by himself; but he would venture to give some observations of a 12-feet Capell and a 16-feet Guibal made at another colliery. The two fans were run simultaneously, on the upcast shaft, at various speeds. The trials were made by the manager and himself, thus: Guibal fan, 80; Capell, 72 revolutions. Guibal fan drew air from the Capell fan inlet. At 80 of Capell fan no air came back. At 88 revolutions the Capell fan drew the air back from the inlet and the chimney of the Guibal fan. The main point was that at 80 revolutions the Guibal gauge was 1·1 inch in the engine house and close to the Guibal fan inlet. The Capell fan, running at 88, gave 1 inch in the drift. He only instanced this to show, if there was anything in this question, that there was an accumulating amount of evidence on the side which he had always taken, namely, that there was a difference between the action on the mine of various fans' gauges. He conceived that it was a question which should be treated purely from a scientific point of view, as it was one of vast interest and wide-reaching results; that it was worth a great deal of experiment; and he considered that, as a question had been raised with regard to the experiments so carefully made by Mr. Deacon at his colliery, that it might be worth while for this Institute to see whether, on the spot, some discrepancy could not be found, or a hole be picked, in the results which Mr. Deacon had ascertained, or that in some way the cause of the difference, about which he had his own theory, might be disclosed.

Mr. J. A. LONGDEN said, to his mind the great point in regard to Mr. Deacon's experiments was that one engine was working on two distinct fans, each of them connected with the same mine. Whilst Mr. Capell seemed to have had numerous experiments, the result of which he could give of his fans running at the same time with the fans of other makers on the same mine, he questioned whether those experiments had been made so public as Mr. Capell seemed to think. Any way, so far as the Capell and the Schiele were concerned, Mr. Deacon's paper showed an absolute comparison. Mr. Crighton appeared to apprehend that the object of the paper was to set the Schiele fan in opposition to the Capell fan. He (Mr. Longden) did not think so at all. Mr. Deacon had these two fans running on a particular mine, and his paper was not written with the intention of showing the superiority of the Capell, but to give the facts of the case as he found them. Mr. Capell had mentioned his name. As far as the Capell fans were concerned,

he (Mr. Longden) was connected with the Waleswood Colliery, where the most successful Capell fan in England had been erected; and at Silver Hill Colliery, this Easter, he had started a Capell fan, which was to give 250,000 cubic feet of air per minute at a water-gauge of 4 inches. In the mine it was to ventilate there was previously a furnace. The pit was 420 yards deep and 15 feet diameter, and the furnace did extremely good work. It seemed to him rather an anomalous thing, after the Inspector of Mines had requested his predecessor to put safety-lamps in this pit, at the same time to have an open furnace. For that and other evident reasons he had put the furnace out and erected the fan. One curious thing he had observed was that the water-gauge in the mine, when the furnace was drawing the same ventilation, viz., 120,000 cubic feet of air per minute through the workings, was the same now the fan was working, although the fan water-gauge must include the friction due to passing through the shaft. He was not prepared to say anything more on this point at present, but he was going to have another water-gauge fixed at the other inlet, and might find some leakage in the pipes to account for the apparent absence of shaft friction in the recorded water-gauge. He had had the wind measured carefully in all the splits in the mine before the fan was erected, and when the machinery had got into proper working order he should have similar measurements made in the same splits, but with the fan as a motor instead of the furnace, and would thus obtain absolute comparisons in the mine itself.

Mr. T. A. SOUTHERN said, in reference to the last remark of Mr. Longden with regard to the fan which he had substituted for a furnace, the water-gauge of a furnace could not all be observed by an instrument; part of the pressure was spent in overcoming the friction of the air in the upcast shaft in which the ventilating pressure was produced. He would ask Mr. Deacon whether the water-gauge was also taken at a few yards back from the fan inlets? Mr. Deacon had entitled his very interesting paper "Comparative Experiments upon a Capell and a Schiele Fan working under similar conditions." With all respect he would suggest that this title was a misnomer, and that it would have been better described as simply a paper on "Experiments upon a Capell and a Schiele fan." To take these tests as evidence of the comparative merits of these two types of fan would be entirely misleading, for he thought, and should endeavour to show, that these two fans were not working under similar conditions, although upon the same mine. The natural ventilation of the mine was given in the paper as 28,339 cubic feet per minute. It was evident that each fan would have to run at a certain speed before its cubical capacity multiplied by the number of revolutions became equal to this quantity, and at that speed it would be just commencing to increase the quantity and to produce water-gauge on the fan-drift. All horse-power spent upon driving the fan up to this speed would be inefficient. The water-gauges which the two fans would be capable of producing at these speeds, if there were no natural ventilation, were probably not very large; but let these two fans be regarded relatively in this respect. The

Capell fan was more than thirty times as large in cubic capacity as the Schiele, the capacity of the Capell being nearly 700 cubic feet, and that of the Schiele only 22 cubic feet; hence the latter would have to make thirty times as many revolutions as the Capell before its efficiency commenced, and as the diameter of the Schiele was two-fifths of the diameter of the Capell, the peripheral speed of the Schiele at this point would be twelve times as high as that of the Capell. Then, as the water-gauge which a fan would produce varied approximately as the square of the peripheral speed, it followed that, however small might be the water-gauges accreditable to each of these peripheral speeds, the greater speed which the Schiele, owing to its smallness, required to attain before its efficiency could begin, placed it under a considerable disadvantage. It was very probable, however, that this great disadvantage was much modified by a superiority shown by the Schiele fan in these experiments, as regarded the output of air per revolution, to which he proposed to call attention. Whilst he looked upon Mr. Deacon's paper as a most useful and reliable record of results obtained by the two fans under the circumstances, he hoped to have shown that the two fans were not, properly speaking, working under similar conditions. To make the matter clear, he ventured to proffer the following proposition:—In the usual mode of calculating the efficiency of fans, a fan would show its maximum efficiency when the mine had a large equivalent orifice and no natural ventilation, and also when the fan was designed to suit the quantities which the mine would pass at various water-gauges; for then the fan would begin to produce water-gauge on the fan drift and to cause a circulation of air, directly it began to revolve. In other words, it would get credit for all the water-gauge it was capable of producing, and for the full quantity of air it was capable of passing. On the other hand, a very small fan working on a mine with a proportionately large equivalent orifice, as was the Schiele in this case, and with a large quantity of natural ventilation, gave very little or no water-gauge, and though it passed a relatively large quantity of air, its ability to pass air was limited, and therefore its calculated efficiency was very low. In an exaggerated way this might be instanced by the case of a fan working in the open atmosphere; it passed a maximum quantity of air, yet, as it produced no water-gauge, its efficiency, calculated in the usual way, was *nil*. Mr. Deacon said, on page 288, "the actual output of the Capell fan, as compared with its theoretical capacity, is very high." It was shown by the table to be from 79 to 88 per cent. But, what about the actual output of the Schiele fan compared with its theoretical capacity? It was a curious fact, and he did not think it had escaped Mr. Deacon's notice (though he did not call attention to it in this paper) that the actual output of the Schiele fan was 463 and 477 per cent. of its theoretical capacity, in the two tests. In other words, the Schiele discharged, during each revolution, more than four and a half times its own cubic capacity of air. He should like to ask whether Mr. Deacon could give any explanation of this. Meanwhile, might not this be taken as a very clear proof that the Schiele fan, owing to its size being so unsuited to a large mine, was absolutely glutted with air

and had not a chance of producing a fair water-gauge. The Schiele fan at work at Shirland seemed, in fact, to have been more fitted to air a sinking shaft than to ventilate a large mine. He begged to suggest to Mr. Deacon that he should close the drift against the Schiele fan or cover its inlets, which could easily be done, then run it at the same speeds as in these experiments—427 and 488 revolutions per minute—and observe what a much higher water-gauge it was capable of producing at these speeds than the water-gauges with which it was credited in these experiments. The water-gauges so observed would be those which the Schiele would actually produce if working under conditions adapted to its size.

Mr. A. G. BARNES thought this subject was perhaps more interesting to colliery proprietors than to anyone else at this meeting. With regard to the question raised by Mr. Deacon's paper, he might mention that his firm had a fan at Grassmoor, made by Messrs. Walker Bros., of Wigan, which was 36 feet diameter and 12 feet across. It had given most satisfactory results. A considerable number of experiments had been made with a view of testing its efficiency, and he should like to mention a few in order to compare them with those of Mr. Deacon. Mr. Deacon said 122,000 cubic feet of air per minute cost £11 8s. 6d. for fuel. For a cost of £11 1s. 8d. at Grassmoor 333,348 cubic feet of air was obtained, measured near the pit bottom, which, as anybody cognizant with experiments connected with fans would know, was against the fan as compared with measuring, say, in the fan drift. Again, for a cost of £10 13s. 10d. there was obtained 225,000 feet of air measured in the returns, and taken from the ordinary weekly ventilation statements, so that roughly 50 per cent. more was got out of fuel (the air being measured in the ordinary returns) than Mr. Deacon got, measuring his air in the fan drift. The cost of fuel, 10 cwt. per hour, at 3s., was the same as Mr. Deacon had taken. After going through very elaborate experiments to ascertain the cost of fuel and the quantity used, the result arrived at was 12 tons per 24 hours. In the case of the 333,348 feet the water-gauge was 2·25 in the fan drift, 2·1 in No. 1 pit, 2·0 in No. 2 pit, 1·3 in No. 3 pit, and 2·2 in No. 4 pit, and for 225,000 feet it was 2·2. The water-gauge in the mine was not measured at the separation doors, but where the returns entered the upcast shaft. With regard to water-gauges, the Grassmoor experiments being simply for the purpose of ascertaining facts proved that there was a considerable amount of variation, and under almost the same experimental conditions they were not to be relied upon. Again, as everyone knew who had conducted experiments with fans, the place of measurement at which the air was taken could also to a great extent alter the apparent efficiency of the fan, according as it was measured near the pit bottom in the fan drift or in the workings. Measured in the pits—Tupton and Black Shale—55 per cent. efficiency was obtained with 193 horse-power and a volume of 222,000 cubic feet of air per minute. Measured in the fan drift, the horse-power still being 193, there was an efficiency of 79·3 per cent., with a volume of air per minute of 318,710 cubic feet. These were absolute facts. The pits working were the Black Shale, Tupton, Ell, and

Dunston coal seams. From the ventilation book, a measurement of 225,000 cubic feet of air per minute showed an efficiency of 47·5 per cent. He thought these figures pretty satisfactorily proved that where there were a number of seams, the Walker fan certainly gave excellent results. He had called attention to these particulars for comparison with the results in Mr. Deacon's paper, and for the information of the representatives of the Capell and Schiele fans.

Mr. E. BAINBRIDGE ventured to hope that no member present, and especially Mr. Crighton, would consider that this paper recorded a fair comparison between a Schiele and a Capell fan. A glance at the figures showed that. The Blackwell Company had a Schiele fan, 5 feet in diameter, and too small for its work, and replaced this by a Capell fan, designed for the work it was doing, and that was the comparison between the two—a comparison which was very useful, because it showed that if a fan like the Schiele fan were put to do a quantity of work much in excess of what it was designed to do, it worked at a great disadvantage. That much was proved no doubt by these experiments. With regard to the general question he was sure that all who had used the Schiele fan, and found the benefit of its regular working, would be indebted to the makers if they could find a place where the Schiele and Capell fans could be tested together, and prove how far the useful effect compares under equal conditions. Mr. Barnes's experiments would be useful on this point, and he hoped that Mr. Barnes would be able to write a separate paper. Anybody who had watched the readings of the water-gauge at the fan must have come to the conclusion that they were apt to mislead. The water-gauge at the separation doors would tell its true tale as a rule. At the fan drift it was not so reliable. He thought Mr. Barnes's figures were very interesting, in giving the quantity of coal the fan took to drive it under certain conditions. In that way a comparison was thoroughly reliable. He must repeat that the case before the meeting was not a fair comparison between a Capell and a Schiele fan; and no doubt the amount of difference in the results would be much reduced if the two fans were not only working under similar conditions, but designed for the same work. He did not think Mr. Barnes's experiments could be compared with those upon this Capell fan, unless he showed also the fuel used in relation to the indicated horse-power. At Shirland it was 10 lbs. per horse-power per hour. At Mr. Barnes's the quantity of coal used per horse-power per hour would probably be much less than at Shirland.

Mr. BARNES—In the case of the 225,000 cubic feet of air the fuel consumed per indicated horse-power of the engine per hour was 5·8 lbs.; the fuel consumed per horse-power in air per hour, 12·2 lbs. At 333,348 feet the fuel consumption was the same per indicated horse-power of engine. I have taken the consumption on an indicated horse-power of 193, which was 10 cwt. per hour.

Mr. BAINBRIDGE—Little more than half what it was at Shirland?

Mr. BARNES—Yes. We have four seams—at 202, 270, 360, and 440 yards in depth. When we put on the topmost seam, the two last being already on the fan,

we got an increase of 40,000 feet for an additional half revolution per minute of the fan; the next seam required one additional revolution, and we got 47,000 feet more.

Mr. C. E. RHODES said he had had an opportunity of seeing the fan at Grassmoor of which Mr. Barnes had just given particulars, and was in a position to corroborate his figures. The only point he thought it desirable to draw attention to was the fact that some portion of the useful effect was due to a compound engine and condenser, which would give an advantage to the Grassmoor arrangement over an ordinary engine. The boiler pressure also was a high one, about 100 lbs., and this assisted the compound engine to work most economically. With regard to the Capell fan, some months ago he visited East Howle Colliery, and made some experiments with the fan there, and was surprised to find the high useful effect obtained. He went carefully into the question, Mr. George May, of Harton Collieries, being with him, and the result of their observations was 81 per cent. of useful effect. Now comparing the results obtained from the Capell fan with those obtained from a Schiele fan, he found that the quantity of air per revolution of the fan was practically the same, but that the Capell fan was driven with much less power, and hence the high useful effect. He could only account for the ease with which the Capell fan was driven as compared with the other, either because of its being much lighter than the Schiele, or in consequence of the fact that it distributed a considerable portion of its air near the centre of the fan, it ran easier. Looking at the matter from Mr. Barnes's point of view, viz., that of the coal owner, he thought it possible that this question of useful effect was one which might be made too much of. He did not think it altogether wise to run the risk of sacrificing the strength which was essential to stand the strain of continuous running year after year for the sake of a slight increase in percentage of useful effect, nor did he think it wise to run the risk of a breakdown, which might involve not only heavy loss in money, but a possible risk of life for the same reason, and therefore great care should be exercised before discarding old and well-tried friends for the sake of a slight increase in useful effect. It was not a question, so far as this meeting was concerned, of either the Capell or the Schiele fan; what was of chief importance was a fan that would give the necessary ventilation with the least possible risk of a breakdown, and secondly, would give this at the least possible expenditure. With regard to the Schiele fans, he had four of these running; two had been running 17 years, one 12 years, and the other 5 years. These fans had continued to give the ventilation for which they were put down, and with a useful effect of from 50 to 56 per cent. No expense in either repairs or breakdowns had been incurred, and as to quantities of air, he might say that one was now giving 210,990 cubic feet of air per minute with a 2-inch water-gauge, and a useful effect of 56 per cent.; but that was without allowing for natural ventilation, and as the shaft in question was 420 yards deep, and 18 feet in diameter, he had very little doubt that there was a considerable amount of natural ventilation. He was informed that at Ashton Moss Colliery there was a natural ventilation amounting to 60,000 cubic feet of air, and he thought,

therefore, in dealing with deep shafts, that the question of natural ventilation should form an important part in making calculations.

Mr. JOHN CRIGHTON said Mr. Capell had stated that the inlet in his fan was 7 feet 6 inches diameter. He was happy to tell Mr. Capell that the inlet into the Schiele 12 feet 6 inch fan was 8 feet, so the latter must get its air easier. There was no constriction at all in the Schiele fan, but the air entered easily into the inlet, and was delivered in a radial line. The fan had two orifices of 8 feet.

Prof. LUPTON remarked as to constricted entrance to fans that the same orifice might be constricted for a large volume of air passing through, and not for a smaller volume of air. Whether the orifice was constricted or not had nothing to do with its absolute dimension or the diameter of the fan, but its proportion to the volume of air it was intended to pass through it.

Mr. CAPELL replied if the orifices into the fan were small, the power of the fan for the future development of the mine was thereby limited; therefore the larger the orifice the better for the increased ventilation of the future.

Mr. A. H. STOKES (H.M. Inspector of Mines) said some of the older members present at that meeting would be amused, instructed, and perhaps alarmed. They were old enough to remember that years ago what was then called the battle of the fans was fought. A new claimant for efficiency, cheapness, and durability had now come forward, and it appeared there was to be another trial of strength. In the former battle no decision was come to—it was a drawn battle. He hoped now that there was newer blood in the Institute a decision upon many of the points left unsettled would be arrived at. With regard to the experiments now under discussion he was an advocate of no particular fan. Let abundant wind be pulled up the shaft after it had disseminated through the workings, and he cared little for the decimal of a penny in the cost. To a colliery manager an extra ton of slack was not of very great moment compared with efficient ventilation. Let the fan be one that would not break down, and of sufficient capacity and power to exhaust the amount of air required to ventilate the mine. The title of Mr. Deacon's paper contained the word "comparative;" this, he thought, was rather unfortunate. Although the experiments were most interesting, they did not satisfactorily clear up the comparison. The size of the one fan was so very much larger than that of the other fan that to set the two fans described to work against each other was like having a battle between a black beetle and an elephant. With regard to the experiments themselves they were very curious. Thus, comparing No. 2 with No. 5 experiment, page 289 :—

Number of Experiment.				Revolutions of Fan.		Water-gauge.
2	...	Capell	...	195	=	3·25
5	...	Do.	...	197	=	3·00

Here an increase of two revolutions of the fan showed ·25 less water-gauge, so that the faster the Capell fan went the less the water-gauge! Take now No. 4 and No. 6 experiments and compare them :—

Number of Experiment.			Revolutions of Fan.		Water-gauge.
4	...	Capell	... 212½	=	3·85
6	...	Do.	... 216	=	3·8

In this case an increase of 3½ revolutions of the fan gave less water-gauge. Upon these figures it would be supposed that the faster the Capell fan ran the less the water-gauge. Such experiments were amusing if not alarming, but they had been placed before the Institute for consideration. The quantities of air might also be compared. Take for this purpose No. 3 and No. 5 :—

Number of Experiment.			Revolutions of Fan.		Cubic feet of Air.
3	...	Capell	... 209	=	120,169
5	...	Do.	... 197	=	120,600

This comparison showed that twelve revolutions less of the fan gave 430 cubic feet more air. With regard to the position of the water-gauge he found that it had been taken directly over the fan shaft. A gentleman present had made some similar experiments, and could get anything from 45 to 65 per cent. of utilized power by manipulation of the water-gauge in this way :—Turning the pipe towards the fan would show a water-gauge of 1·85 ; turning it from the fan 1·40, or nearly half an inch less water-gauge. At right angles 1·75 ; and with the pipe straight up 1·80 ; the fan going at the same speed, and all done in ten minutes.

Mr. CAPELL said, holding the water-gauge facing the current, the velocity of the air going across the water-gauge counteracted the suction up the pipe ; that was to say, caused a depression. Holding the gauge against the current, the gauge would rise and go to the contrary direction to the suction side. Naturally enough, facing the current would not give the true gauge, but a gauge modified by the velocity of the air entering against it. That was why in Germany, where experiments had been carried to a fine point, they put the gauge at right angles to the current, and with its edge ground to knife sharpness.

Mr. DEACON would like to state that these experiments were made from an unbiassed point of view for the benefit of the mining engineers of the Institute, and for the purpose of giving the results of the two fans as they stood, and not as tests of the general efficiency of the two fans, and as against the value of the Schiele. It would readily be seen he could not manufacture better results. The results were those he found ; if they were not as satisfactory as in some other Schiele fan, he was sorry for it. In reply to Mr. Crighton, he would say that the difference between the two water-gauges at the separation doors and in the fan drift was no doubt very large indeed. He thought he could explain that to some extent by mentioning that the upcast pit was very considerably blocked with pump trees, lifts, and steam pipes, and at two points, its area, which should be 136 feet, was reduced to 56 feet. That would go a long way to explain the difference between the water-gauge at the fan drift and the separation doors. With regard to the low water-gauge in the first Schiele experiment, where it showed on the separation doors ·45 as against ·7 in the corresponding Capell experiment, he could only explain this difference by assum-

ing that the water-gauge in the drift in the same experiment was a higher water-gauge than was really due to the quantity of air produced. He thought it was partly due to the high velocity of the current. Therefore, possibly, if the experiments had been made with equal water-gauges at the separation doors, instead of equal water-gauges in the drift, there would have been a much lower water-gauge in the drift in the case of the Schiele. Consequently, so far as these experiments affect the useful effect of the fans, this particular point operates in favour of the useful effect of the Schiele fan. In reply to Prof. Lupton, who had, he thought, compared in one instance the water-gauge in the pit with the water-gauge in the fan drift, he must say that he did not see how that could be done. Any two water-gauges in the drift, or any two in the pit could be compared, but he did not see how comparison could be fairly instituted between the water-gauge in the pit and the water-gauge in the fan drift. Perhaps, however, he had not clearly understood Prof. Lupton's argument. Mr. Capell had referred to different rules for theoretical water-gauge. What was called the old rule, $V^2 + 2g$, approximated more nearly to the actual water-gauge than the new rule, $V^2 + g$. He should like to know why there was any necessity for an alteration of the rule, and why the new rule should vary to the extent of 100 per cent. from the old one, when the old rule was much nearer the actual water-gauge than the new rule. In reply to Mr. Southern, he would observe that no experiments were made upon the water-gauge a few yards from the fan. He thought Mr. Southern made a remark that the comparison was misleading. It could hardly be said that the comparisons were misleading when they were actual results obtained on the spot. As to the body capacity of the Schiele fan, that was inadvertently omitted when the tabulation was made, but as Mr. Southern observed, the proportion of output to body capacity was very large. In that respect he believed Mr. Southern's figures were about correct. He could not explain why this ratio should be so large in the Schiele. He simply gave the fact that the proportion of output to body capacity of the Capell fan was very large in comparison with the Guibal fans that had come under his notice. With reference to Mr. Barnes's remarks, a good deal of the information he was going to ask had been elicited by Mr. Bainbridge, but he should like to ask one more question as to the quality of fuel used. A great deal depended upon that, and in the Shirland case the fuel was of the worst description got out of the pit. It was something which could not be sold at any price except in a panic, and the engine upon which these experiments were made was a high-pressure engine without expansion gear; the boiler pressure was 50 lbs., the steam was brought a long way, and was very wet.

Mr. BARNES—The fuel used at Grassmoor was screened slack.

Mr. DEACON—With reference to Mr. Bainbridge's remarks that it would be satisfactory if some regular position of the water-gauge could be decided upon, so that fan tests could be more comparative, no doubt the separation doors, if their position were similar in all pits, which, however, they were not, would be a comparatively similar position for the water-gauge to be fixed; but in this case the full

work done by the fan would not be represented. So far as his experience went the water-gauge was generally fixed in the fan drift, and not in the pit. If he had made his experiments with the water-gauge at the separation doors, the comparison would have been of little use. Replying to Mr. Stokes's remark as to a ton of coal not being of much value, colliery proprietors had their own opinion, and if one ton of coal was not of much value, many tons were of much value. Mr. Stokes had pointed to the results of some of these experiments, and he was obliged for it, because he had omitted to state in the table that in experiment 5, where the water-gauge was 3·00 inches for 120,600 cubic feet of air, the separation doors were slightly opened, so as to produce exactly a 3-inch water-gauge, the object being to test the guarantee of the makers that the fan should give a certain quantity of air with a 3-inch water-gauge. The other experiments, he thought, would be found to agree theoretically as nearly as possible with the practical results. As to the position of the water-gauge, it would be seen he had made a number of experiments with the object of trying to get at the true place in which to fix the gauge. He then took the mean of these results and therefrom determined the fair position for the gauge; it was very important to ascertain the true position for the water-gauge, as a large apparent difference of useful effect could be arrived at by varying its position. Its proper place to give correct results must be ascertained before detailed observations could be relied on. That he had endeavoured to do by making these trials with the water-gauge before fixing on any position.

The CHAIRMAN—Gentlemen, is it your pleasure that the discussion shall be adjourned or closed?

Mr. LUPTON—I move that it be adjourned.

The proposal was seconded and carried.

DISCUSSION UPON MR. G. BLAKE WALKER'S PAPER "ON COAL-GETTING BY MACHINERY."

Professor LUPTON said this was an interesting and instructive paper. He should, however, venture to criticize it in one or two points, but would do so with the utmost respect to the author, and not with the least intention of detracting from the value of the paper. In the first place, the suggestion that colliers do not now put forward the same amount of physical exertion that they used to do in days gone by, he thought, was not entirely accurate. Also, the author's opinion, that in the future the most successful coal-cutting machines would be actuated by electricity, was not conclusive; and his remarks as to the great amount of loss of power in the use of compressed air for coal-cutting were capable of explanation, and certainly required confirmation. Without in the least degree desiring to limit electricians in anything they might do in the future, he did ask for a little evidence of the superiority of electricity over compressed air. As soon as that evidence was brought forward he should be ready to welcome it and make use of it. Mr. Walker

had limited the useful effect of compresed air to 20 per cent.; but with reasonable care he (Professor Lupton) had no doubt two or three times that amount, from 40 to 60 per cent. of useful effect, might be got. Because, at those collieries where they produce material which will burn, but which, as had just been stated, could not be sold at any price, there had not as yet been put down the most efficient air-compressors, and consequently the results in these cases did not show a high theoretical efficiency, it did not follow that a high efficiency was unattainable. Compressed air was so suitable to be taken into the innermost recesses of a mine that he did think it a mistake to advocate with confidence the use of electrical machines as superior in efficiency without some proof of the proposition. He had had some little experience of coal-cutting machines, and had carefully studied them for the last twenty-five years. It was twenty-five or twenty-six years since he went down the pit, which was now under Mr. Walker's charge, to start the first of the coal-cutting machines in that pit. He had watched them with great interest since, and it seemed to him that the difficulty in getting coal-cutting machines more generally used was not because colliers would not put forth great physical force, but because they actually did put forth so much force that it was difficult for steam power to compete with them in seams of the kind chiefly wrought. These were the actual facts as against the theories of people who spoke *a priori*. The fact was, in ordinary seams coal-cutting machines had not hitherto been able to maintain themselves against hand labour as a general rule; but where the seam was thin, or the holing hard, or the management more than usually determined, they were more successful.

Mr. LONGDEN said, in his opinion, compressed air as a motive power was extremely wasteful, and electricity was by comparison distinctly economical. Mr. Blake Walker's paper was one of extreme value, and he should be sorry indeed if the discussion were to be closed without allowing full time for discussion. The question of electrical coal-getters had been taken up very thoroughly by the Institution of Civil Engineers, and Mr. Arnold Lupton had replied, upholding compressed air, and had been replied to at great length by electrical engineers. Without disparaging mining institutes, he thought the electrical part of the problem had been maintained by the civil engineers in a more thorough manner than mining engineers could do. He was now speaking as a mining engineer, and with the knowledge that electrical engineers were in the room. In a short time he purposed asking the members of the Institute to see air-compressors and dynamos in use at collieries with which he was connected.

Mr. C. E. RHODES said this question of coal-cutting machinery was a most important one, especially for those working thin seams where the waste due to cutting by hand labour was an important element, and as he had had many opportunities of seeing Mr. Walker's coal-cutting machinery at work at the Lidgett Colliery, he could speak with some amount of confidence upon the subject. Anybody who, like himself, had had an opportunity of seeing the system in operation there, would come to the conclusion that the commercial prosperity of that colliery

was due to the admirable manner in which this system of coal-getting by machinery had been applied. There was no doubt that the seam, if it had to have been holed by hand, with the strong floor that exists there, would have been simply chopped to pieces in the process of holing, and the saving in small, due to cutting by the machine, with such a valuable coal as the one in question, had made all the difference between a commercial success on the one hand, and a heavy loss on the other. In addition to the advantage just indicated there was another, and that was that the coal, when it was once holed, could be got down and practically filled into corves in a great measure by unskilled labour; that was to say, the skilled labour could be confined to men following the machine and timbering the places and making them safe after it. There was no doubt in his mind that in the future the introduction of coal-cutting machinery would form an important point in connexion with mining. He lately introduced a heading machine which he had previously seen in operation at the collieries of the Staveley Coal and Iron Co., and the result was that they were enabled to head a number of yards in a day which previously would have taken a week by manual labour. He did not think so much was saved in the cost per yard, but there was an enormous advantage in being able to open out a colliery at the rate of 60 yards per week, and thus develop and prove a coal-field with a rapidity it would be impossible to achieve by any system of hand labour. With regard to the power for driving this machinery, there could be no two opinions as to the economy of electricity over compressed air, not only in respect of the useful effect obtained from the initial power, but also the comparative economy in conveying it. No one could get with compressed air more than from 30 to the very outside 40 per cent. of useful effect, at least he himself had never been able to do it, but with electric machinery there was no doubt a very much higher useful effect could be obtained. The difficulty, he said, with regard to the application of electricity, especially in fiery mines, was the danger of sparking, and it seemed to him an absurdity for coal owners who had gone to the expense of introducing safety-lamps, abolishing gunpowder and all explosives of a nature calculated under any circumstances to ignite gas, which there was no doubt had involved an increased cost of production of from 3d. to 6d. per ton, then to introduce a power, simply on the ground of its economy, which threw off sparks, and which in itself therefore was as bad as a naked light. This was the only, but grave, objection he saw to the introduction of electricity for mining operations. It was a difficulty possibly which in the immediate future electricians would be enabled to overcome. Such enormous strides had been made in the last few years by the ingenuity of those gentlemen to whom all owed so much that he thought they would be able to achieve what was essential to the safety of those employed in mines, if electricity was to be largely used, and that was to overcome the danger due to this sparking. It was a point, he thought, that all would agree to commend to their special efforts, and he had no doubt that during the next few years some means would be discovered to obviate this grave danger.

Mr. DEACON said, with reference to the last remark, there was an electrical machine or appliance somewhat of the type suggested now at work. It was called the Davis and Stokes safety commutator, in which the brushes being placed inside the commutator, instead of outside, and the whole cased in, all the sparking took place inside the commutator chamber, and could not communicate with the air of the mine. It had been run for a week perfectly satisfactorily, and he (Mr. Deacon) believed he was to have the honour of fixing the first in a pit of the Blackwell Company. In reply to Prof. Lupton, he added that it would be employed for pumping in a colliery which was worked with safety-lamps.

Mr. G. J. BINNS did not think there was much reference in Mr. Walker's paper to the Harrison coal-getter, and as he had failed in obtaining information as to where that machine could be obtained in England, he should be glad if Mr. Walker or any other gentleman could tell him. It was one which was largely used in America, and its use obviated many of the objections which might be raised to the ordinary type of rotary coal-cutting machine. It was a percussive coal-cutter; in fact, a rock-drill on wheels, which could be moved anywhere in a moment. One man could work it, holding the handles, while another shovelled away the *débris*. It was a very small machine, and very inexpensive. There was another machine of the same kind, made by the Ingersoll Rock-Drill Company, which appeared to be as good as the Harrison. The object with the rotary coal-cutter was to make the whole machine fast to the rails; whereas the object of the other was to have it as free on the road as a perambulator in the street.

Mr. J. R. GILCHRIST apologized for the absence of Mr. Walker, who had fully intended being present at this discussion, but was called away at the last moment. In his absence, he (Mr. Gilchrist) should have been glad to answer any questions that might have been put. But only one remark appeared to call for any comment on his part, and that was made by Professor Lupton, who appeared to be somewhat in error as to what Mr. Walker mentioned as the percentage of useful effect that could be got out of compressed air. He understood Professor Lupton to remark that Mr. Walker maintained that only 20 per cent. of useful effect could be obtained, whereas referring to Mr. Walker's paper, he said, "If 40 per cent. of the power put into the steam cylinder issues from the air cylinder into the mains, it must be considered an exceedingly good result," and in referring to the 20 per cent., Mr. Walker was applying this as the probable useful effect at the face of the workings, after allowing for loss of leakage, etc., at the numerous joints of pipes. As regarded coal-cutting machines, he believed they would be more largely used in the thin seams than the thicker ones, and could corroborate the remarks made by Mr. Rhodes as to their working in a thin seam at Lidgett Colliery. There, the underholing was very strong, and it was a case where he did not think they could get manual labour to do it. Coal-cutting machines enabled this colliery to work to advantage; whereas without machines it could not be successfully worked, at any rate, commercially.

Professor LUPTON moved, Mr. JACKSON seconded, and it was agreed *nem. con.* that the discussion be adjourned.

The CHAIRMAN said they were not in a position to discuss Mr. Russell's paper, and therefore the proceedings were now at an end. He must congratulate the Institutes on their first joint meeting, and hoped that it was only the first of many meetings that might be held jointly to the benefit of each institute.

Mr. LONGDEN moved, and Professor LUPTON, seconded a vote of thanks to the Chairman, which was carried and duly acknowledged.

DINNER AT THE ROYAL VICTORIA HOTEL.

MR. JOSEPH MITCHELL, PRESIDING.

After the usual loyal toasts,

Mr. THOMAS CARRINGTON (Past-President of the Midland Institute and Vice-President of the Federated Institution of Mining Engineers) said that he only supposed he had been asked to propose the toast which had been placed in his hands in consequence of the absence of Mr. Parker Rhodes (whose seat he occupied) and Mr. Emerson Bainbridge. As that was so, and as he had been called upon at a moment's notice, he trusted they would extend to him a good deal of indulgence and forbearance, particularly as he had, as it were, to propose two toasts in one. They were, "Success to the Chesterfield and Midland Counties Institution of Engineers and the Midland Institute of Engineers," and the "Learned and Scientific Societies." In proposing a toast which involved the healths of the "Mining, Civil, and Mechanical Engineers," and "Learned and Scientific Societies," he was really proposing the healths of their "noble selves," and doing it twice over, too. No institution of civil, mechanical, or mining engineers could be carried on successfully without due attention to the laws of nature; in fact, the application of physical forces of various kinds, and their conversion, adoption, and application to the uses of man was their daily occupation; therefore they as engineers must be ever closely identified with the learned and scientific societies, the latter being as it were the pioneers in discovering physical laws which it was the duty and province of engineers to apply for the purpose of obtaining practical results. During the last few years it had become more necessary than ever that they should keep pace with the times; for instance, they had seen already what an investigation of the laws of the forces of nature with regard to electricity had resulted in, and what marvellous developments had followed and will still follow. And when they remembered that in America there were kindred Institutions, who were as much alive as they were to the benefits of careful observations and verifications of facts in regard to physical science and the conclusions to be drawn therefrom, it was more incumbent on them than ever to carefully investigate these same laws and to interrogate physical phenomena to the fullest extent. With regard

to trade competition from America, he heard of a very striking fact the other day which showed how closely America was running this country in the production of coal. He received a letter the previous day from the representative of his firm in Hamburg, in which he stated that he had just witnessed the arrival of an American steamer there with a cargo of 3,600 tons of Pennsylvanian coal (the first to arrive in Hamburg), and that in consequence the price of German coal went down 2s. per ton. He did not know whether it had recovered. This only showed to them how very closely American competition was treading on their heels in European markets, where they had always previously thought they were *facile princeps*, and that they could hold their own. He did not wish, in proposing the toast, to wander from the scientific and professional considerations it properly involved to that of purely mercantile competition, but still the latter was the really practical test of the position of affairs at the present time, as well as at most times, having regard to skilful and economical management based on scientific knowledge and principles. He did urge upon them, although he did not think there was any need for him to do so, the great importance of maintaining in full efficiency the most important and, in fact, essential work of such Institutions as those he had the honour to propose the success of, which were really the highest forms of completed scientific and technical education. He coupled with the toast the name of his very old friend, Mr. Jackson, the President of the Chesterfield and Midland Counties Institution, whom he was glad to see amongst them again in good health after his late severe accident.

Mr. JACKSON, who was heartily received, on behalf of his Institution tendered hearty thanks to Mr. Carrington for the way in which he had proposed the toast, and also for the kind manner in which his own name had been mentioned and received. He felt they had done that day, so far as the Chesterfield Institution was concerned, what they ought to have done some years ago, for he was convinced that they should take every opportunity they could of meeting together and discussing those interests which they both had to so great an extent in common. No doubt they had made that day new friends. It was always very pleasant to make them, and a very much greater pleasure to retain them. He sincerely hoped that meeting was the beginning of a series of meetings, and that the result would be improvement in the work in which they were engaged, and would be to the mutual benefit of each and all concerned. They had had the opportunity of seeing a colliery new to a great many of them. They had seen a very large and fine plant; and he was quite sure some of them would take away much that would be instructive. One thing which struck him very favourably was the curious fact that they got a great force—sometimes out of nothing. When they were inspecting those boilers, and looking at the furnace feeders, Mr. Bainbridge said the slack which they used was utterly valueless, and he could not help thinking that though it had no value it was doing a great amount of work. On behalf of the members of the Chesterfield Institution, as the visitors, he was sure he could say they enjoyed the visit exceedingly, and he hoped it would not

be long before they would have an opportunity of giving the members of the Midland Institute a welcome in the district with which they were themselves connected. He thanked them very heartily.

The CHAIRMAN, in responding to the toast of his health, remarked that they had been very pleased to have the opportunity of welcoming the members of the Chesterfield Institution at Sheffield. When at the Federated Meeting at Newcastle, he had the pleasure of sitting next to their worthy Secretary (Mr. Howard), and they talked about the possibility of such a meeting as had been held that day, when they could meet and discuss the Federated papers together, and so extend their knowledge on points that had been raised by the various papers. He was sure he must congratulate both Institutes on that day's discussion. It had been a very great pleasure to see so many present, and he hoped, as Mr. Jackson had said, that would only be the beginning of many such gatherings, and good results would follow, so that each district might benefit by the knowledge which would be brought to bear on the various arguments and discussions, that their respective members might not be able to say they did not know how things were managed in the adjoining county, but, on the contrary, that the results of what one institute did the other knew of. He thought that they had begun very well by having the meeting there that day, and concluded by thanking the members of the Chesterfield Institution for their attendance.

DESCRIPTION OF THE NUNNERY COLLIERY, SHEFFIELD.

This colliery is a typical instance of a coal mine having an excellent position for the purposes of trade, but great natural disadvantages. These being :—

(1) A straggling coal-field.

(2) A large quantity of water which comes by levels to the bottom of the shafts, and a small quantity which is very difficult to deal with in the dip workings.

(3) Numerous faults which militate against the economical production of coal.

The colliery, as regards the Silkstone Seam, is practically exhausted within 2,000 yards of the shaft; but there is a large coal-field adjacent for which the present plant is available, and another large coal-field for which a new winning will have to be made.

The following are some of the chief features of the colliery :—

1.—With the conditions already mentioned, and with water in every working place to the dip, and with workings in some cases two miles from the shaft, an output of 20,000 tons per fortnight has been reached during the past few months.

2.—The Silkstone winding engine is a double 30-inch cylinder engine, with 5-feet stroke, working an 18-feet drum. The Parkgate winding engine has two 24-inch cylinders, and 4-feet stroke, working a drum of two diameters, viz., 16 feet 6 inches and 10 feet 6 inches. Both engines are under the same roof and are fitted with steam and foot brakes. A special appliance for signalling in the winding-engine house indicates to the eye of the engineman how many raps have taken place.

3.—The shaft guides consist of steel rails, which are twice the cost of ropes in the first instance, the only advantage of them being that the cages can be brought about one inch closer together. The wear and tear of cages is reduced by providing spiral springs at the bottom of the shaft, on which the cages drop, the usual shock being entirely prevented.

4.—The tubs are fitted with the Elliott lubricator, one application of oil to each per month being sufficient in ordinary working.

5.—The haulage in the Silkstone Seam is carried out by a head-rope 3,700 yards in length, which works an incline in-bye, bringing 42 tubs up a gradient of 1 in 7 at the steepest part to a point a mile from the shaft, whence they are brought by a main and tail-rope engine to the pit bottom.

Both engines are worked without spur gear, and the single rope engine is condensing and is fitted up with special clutch gear. Both engines have two 24-inch cylinders, and are erected on the surface, the ropes going down the shaft in pipes.

6.—An endless rope, 6,300 yards long, is used in the Parkgate Seam for working the haulage. In the East Parkgate district, another endless rope, 3,200 yards in length, is used for the combined purpose of hauling and pumping. Three pumps are worked by means of this rope; the pumps are double-acting plunger pumps, geared to 5-feet driving pulleys, fixed horizontally, round which the rope works. The pumps are capable of pumping 50 gallons per minute each.

7.—Another endless rope is used upon the surface for the purpose of carrying the Parkgate Coal to the main heapstead, and carrying stones, etc., to the dirt heap. This rope is 900 yards in length, and is worked by two pulleys having five and four grooves respectively.

On the dirt tip incline, a screw clip is being used, and is made of wrought iron, the weakest part being the "loop" which is constructed so as to give way when the tub gets off the road. The jaw which grips the rope is about five inches in length and is tightened by a screw. It is capable of hauling ten tubs and can work on steep gradients and round curves.

On the other incline an automatic detaching clip is used. This was designed with a view of having the tubs automatically detached from the rope, which is gripped by two jaws, jointed at the top, where the clip is attached to the draw bar of the tub. An arm stands out on each side from the cap or hoop. These arms strike against a sloping surface at the point of detachment and by raising the cap set the tub at liberty. The raising of the cap forces the jaws apart and liberates the rope. This clip has worked very well with single 10 cwt. tubs upon a gradient of about 1 in 7.

8.—The character of the underground works and the faults which have had to be overcome are shown by the size of the spoil heap, which is estimated to contain about 500,000 tons of stone, most of it being burnt.

9.—The pumping at the colliery is very heavy, power being provided for raising 6,000 gallons per minute. A large Cornish beam engine with 86-inch cylinder and 10-feet stroke, is kept constantly at work. To either end of a plated beam are attached the pump spears, working 18-inch and 16-inch sets to the Silkstone Seam at a depth of 220 yards, and pumping up 110 yards to the Parkgate Seam, to which there are two 26-inch sets at a depth of 110 yards, these two being equal to 2,000 gallons per minute.

There are three duplicate horizontal, direct-acting, compound pumping engines underground. They are fitted with 15-inch rams, and are each capable of pumping 1,000 gallons per minute. One pumps from the Silkstone to the Parkgate Seam, and the other two from the Parkgate to the surface.

10.—Seven steel boilers, 30 feet long by 7 feet diameter, were erected in 1884, and are all fitted with the Proctor mechanical stoker, which enables a very inferior class of coal to be used for firing. There is also fitted to this range of boilers an economizer, through which water is sent into the boilers at a temperature of from 280 degs. Fahr. to 310 degs. Fahr.

An Arnold boiler has lately been erected, 30 feet long by 8 feet diameter. The main feature of this is that in place of Galloway cross tubes, a longitudinal tube is fixed, running from near the back end to a point about 4 feet behind the bridge, and the flues themselves are in barrel-shaped sections, welded, by means of which thinner plates can be used, and no rivets are exposed to the fire.

A Carroll water purifier is fixed to the Arnold boiler. The feed-water is admitted through a flat pipe having two passages. The water passes first through the lower half, and then through the upper half into the boiler. The deposit and residue from the water settles in this pipe, and is blown off at intervals.

11.—Ventilation is produced by a 30-feet Guibal fan, which has been working about twenty years. A new engine to drive it was started in 1890. This is a compound engine fitted to work with fourteen ropes. Six are found to be sufficient to do the work at present. Two appliances of interest are in use in the fan-engine house, the first being a mode of ventilating the house by taking a pipe from the roof into the fan chamber, and the second is a mode of utilizing the ordinary steam gauge for the purpose of continuously indicating the speed of the fan.

12.—The dry separation plant at the surface consists of three sets of jigging screens, which separate the coal into three sizes, and four large travelling belts on which the dirt is picked out from the coal. By the means provided, the coal is mechanically divided into twelve different sorts, and the plant is capable of dealing with 150 tons of coal per hour. A special plan is in operation for disposing of the dirt picked out from the coal, by dropping it down below the rails.

13.—The coal is washed by an ordinary trough machine, and the washed coal is taken a distance of 900 yards by water, and is received into large hoppers close to the coke ovens. A small locomotive is used for filling the coke ovens with despatch, and has been at work about fourteen years.

14.—The electric plant at the colliery consists of an Immisch dynamo and motor, the current being transmitted through a cable to the motor fixed at a distance of 3,500 yards from the dynamo.

The dynamo is compound wound, and gives at 880 revolutions, 520 volts and 22 ampères. It is driven by the fan engine, the speed being obtained by means of a counter-shaft with pulleys, driving two leather-link belts. The power required to drive the dynamo at full load is 22 horse-power.

The large driving shaft is geared to the engine shaft by a spiral form of friction clutch, and 37 revolutions per minute of the engine give a speed of 880 revolutions of the dynamo.

There are two 7/16 bitumen insulated cables leading from the dynamo to the motor, which is rated at 16 horse-power when absorbing 525 volts and 25 ampères.

Power from the underground motor is transmitted by means of a leather-link belt on to a counter-shaft, which has spur gearing of 5¼ to 1 on to the pump shaft.

The pump is a three-throw ram pump, and is delivering 50 gallons of water per

minute through 2,000 yards of 4 inch pipes with a head of 385 feet, this being equal to six horse-power in the water, neglecting friction in the pipes.

The cables are taken down the shaft in pipes, and are fixed to the props in the pit with wooden clamps; they are quite slack, to enable them to give way in case of a fall of roof.

15.—A Cockson fan is at work at the Woodthorpe pit, and is driven direct by a Willans & Robinson engine, running 280 revolutions per minute.

A Robinson coal-washing machine has been in successful operation at this colliery for a number of years.

SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

GENERAL MEETING,

HELD AT THE MASON COLLEGE, BIRMINGHAM, ON JUNE 4TH, 1891.

MR. C. H. TREGLOWN, PAST-PRESIDENT, IN THE CHAIR.

The minutes of the last meetings were read, confirmed, and signed.

The following gentlemen were unanimously elected Members of the Institute:—

MEMBERS—

Mr. W. E. Marples, Rugeley.

Mr. A. E. Cattermole, A.R.S.M., Handsworth.

Mr. Arthur Parton, Willenhall.

OLD MINING IMPLEMENTS.

The SECRETARY read a letter from Messrs. J. Hough & Son, expressing their willingness to present to the Institute the antiquated mining implements which were exhibited and described by Mr. Scott at the last meeting; and upon the motion of the CHAIRMAN, seconded by Mr. WARDLE, a vote of thanks was unanimously accorded to Messrs. Hough & Son for their gift.

MEETING OF FEDERATED INSTITUTION.

The SECRETARY reported that the Federated Institution had approved of the dates suggested by the Institute for the conference in Birmingham, September 22nd and 23rd, 1891.

COAL DUST COMMISSION.

A communication from the Royal Commission on Explosions from Coal Dust in Mines, inviting the Institute to nominate two or three gentlemen from the South Staffordshire district to give evidence before the Commission, having been read by the SECRETARY, it was resolved that the President (Mr. J. Williamson), Mr. W. B. Scott, Mr. A. Sopwith, and Mr. John Hughes be appointed in accordance with the invitation of the Royal Commissioners.

POËTSCH SYSTEM OF SINKING SHAFTS.

The SECRETARY also read a communication from Mr. A. Gobert with reference to the freezing of flooded shafts, and inviting members to inspect a mine at Pont-à-Vendin, where the process of freezing had been performed.

DISCUSSION ON MR. W. FAIRLEY'S "NOTES ON COLLIERY EXPLOSIONS."

A letter was read from the President (Mr. J. Williamson), who was absent through illness, with regard to the discussion on Mr. Fairley's "Notes on Colliery Explosions," which was read at the last meeting. The discussion upon Mr. Fairley's paper was to have been taken at this meeting, but the President having promised to read a paper bearing upon the subject, the CHAIRMAN said it was no doubt very desirable that the discussion upon the two papers should be taken together.

Mr. FAIRLEY having expressed his willingness for a postponement of the discussion on his paper, it was decided to defer the discussion until Mr. Williamson's paper had been read.

Mr. WILLIAM GRIMMITT then read a paper upon the "Apparatus for the Prevention of Winding and Overwinding Accidents at Collieries and Blast Furnaces," which was exhibited at the annual meeting.

APPARATUS FOR THE PREVENTION OF WINDING AND OVERWINDING ACCIDENTS AT COLLIERIES AND BLAST FURNACES.

By William Grimmitt.

It is certain that all men whose duty calls them to go down into deep mines have to depend chiefly, while in the shaft, upon the efficiency of the engines and the steadiness of the engineman.

When these fail—for, good though they both usually are, they do fail too frequently—some automatic contrivance is needed that will act in such a manner as to properly arrest the cage, and preserve the lives and limbs of its terrified freight.

To men who are ascending at a very high velocity the presence of a detaching hook would scarcely give confidence, while to men descending under perilous conditions the hook would be worthless. Imagine a case similar to the Houghton Main disaster. Ten men were coming up with a frightful and rapidly accelerating velocity. The detaching hook failed when the supreme moment came; and had it accomplished all that was expected of it those ten men would have been killed all the same.

What was wanted in that case was some kind of controlling machine, which, the instant the engineman failed in his duty, would at once shut off the steam and then apply the brake gradually, but firmly, so as to bring the engines quietly to rest. There is always time to do this, if, at the right moment, it is properly set about.

A preventive contrivance to be of any value must unerringly find the right moment, and then, without the least faltering, take from the engines the power to do mischief. All torsions and shocks must be carefully avoided, and, of course, there must be no sudden stopping of men; therefore the sudden application of brake power is not to be thought of.

Men may be descending the shaft when the engineman has lost control of his engines from some cause; or the crank pin may have broken; or a steam pipe may have burst; or he may have forgotten that the intermediate bolts are on, or that a temporary scaffold is in the shaft.

All these points, and more, have to be watched; and a preventive apparatus, which is competent to come to the rescue in all these various dangers, and will, moreover, always compel the engineman to give his most careful skill and attention to his duties, may surely be said to possess practical value. Such a machine is now respectfully submitted to your careful inspection.

In carrying out the invention two vertical cylinders of equal dimensions are employed, A^1 and B^1 (Figs. 1, 2, 3, and 4, Plate XXI.) There is a ram in each cylinder, occupying about half its capacity. A smaller cylinder A^2 is connected with A^1, and another smaller cylinder B^2 is connected with B^1. There is a float or buoy in each of these smaller cylinders.

About 3 feet from their base the two large cylinders, A^1 and B^1, are connected by the pipe C C. This pipe is intersected by from five to seven tubes. If there are no intermediate insets, only five tubes are needed. Each of these tubes contains a plug, which works more or less loosely up and down.

The rams and plugs are raised and lowered from a small shaft D at the top of the apparatus, which is preferably driven from the winding drum shaft of the engine.

The floats act independently, and are attached to the levers E^1 and E^2 respectively, and both of these levers are attached in turn to the lever F. Now, if this lever F can be brought down at the right moment, by either of the floats, until it engages with one or other of the circle of studs, shown at L, a safe and steady stopping of the engines is assured. Therefore, before going any further, the writer will try and show how this is effected.

Let the whole system of cylinders and tubes be filled with oil or water up to the point marked on the tablet "water line." Then let the quickest allowable wind be decided upon by the manager or colliery engineer, and the regulating valve X set and locked, so that this speed shall not be exceeded. Next, ascertain the exact points in each run where it is imperative to reduce speed, and adjust the plugs I^1 and I^2, so that at these points one or other of them may be across the passage in the pipe C C. Imagine the cage at the top about to descend the shaft. The ram H^1 is also at the top, and so is the indicator G^1. As the engineman commences the downward journey, the ram H^1 displaces the water in the cylinder A^1, and sends it into the cylinder B^1, the ram contained in which is proportionately ascending to make room for it. The engineman must regard the ascending indicator G^2, and when it has reached the word "caution" he must begin to slacken speed, because the plug (in this case I^1) is obstructing the flow of the water from A^1 to B^1. He must consequently so reduce the speed of the ascending ram that the volume of it raised above the "water line," in a given time, shall not exceed the volume of water passing the obstructing plug in the same time. If this be properly attended to the water will nearly keep its level, the floats will not fall, and of course the lever F will not engage with the stud circle L. But suppose the engineman does not properly slacken speed, then, clearly, owing to the ascending ram vacating the lower part of its cylinder faster than the obstructed water can supply its place, there must be a fall of water in that cylinder, and also in the float cylinder connected with it. Accordingly, the float follows the falling water and pulls down the lever, which simultaneously brings down the lever F into the stud circle set in face of the wheel L. The lever F then instantly makes a short side movement, turns a pin, which sets free from the lip N the lever N^1, this, in falling, liberates the steam lever P and the brake lever Q, from their supports N^2 and N^3.

Although after a plug has been lowered across the transverse pipe C C from "caution" to the top, and will not be raised clear of the water passage until the descending indicator has traversed a certain distance the reverse way, still the engineman may go as fast as is required from the top downwards, because the float

lever which has to receive the next pull downwards is weighted on its resistance arm by one of the weights R^1 or R^2, until the said plug is raised clear of the transverse pipe, and the water resumes its level.

When men are about to ascend or descend the shaft, the banksman gives the signal to the engineman, and at the same time, by means of a wire running from the pit top to the apparatus, causes the T-shaped lever shown in the front elevation to raise the pin T. At some point decided upon by the manager this pin begins to lift the lever T^1, which simultaneously lifts an additional plug (General Rule 26). This plug has a rather larger diameter than the plugs I^1 and I^2, so that it will offer a greater obstruction to the passage of the water, and a much slower speed for the last two or three revolutions of the engine will therefore be necessary to keep the machine quiescent.

If two seams are being drawn from one shaft, accidents may happen whenever the bolts at the top seam are left on, or put on beneath the descending cage, and the engineman intends running to the bottom. By connecting the said bolts to a special plug, the water supply will be partly shut off at a suitable point, from the cylinder containing the ascending ram, and then, unless the speed of the engine be quickly reduced, the float appertaining to that cylinder will bring down the lever F, with a result before in part described. The moment these intermediate plugs have done their work they get out of the way, so as not to hinder the engineman in the continuation of his journey.

Again, supposing the banksman hears something wrong in the shaft, or sees something in connexion with the winding to alarm him, he can, as he stands at the pit mouth, by a touch of his finger drop a special plug across the transverse pipe, which will stop all the water and quickly bring down the lever F.

When shaft repairs are going on two special plugs are adjusted, one for each way, the operation of which will compel the engineman to go steadily up and down, and also to stop quietly when he has lowered his cage or "bowk" to a temporary scaffold, or any other given point.

"Turning again" cases are very rare in these days, but they do occur sometimes. They can easily happen with engines, fitted with loose eccentric or tappet actions, or with single engines of the fast cam or link principle, if the crank pin snapped, or even with coupled engines if the steam pipe were to burst. In these cases the apparatus would instantly prepare for action, and would in a few moments unfailingly stop the drum before the one cage could rush out of the top, or before the other could be dashed to the bottom.

The steam in all the cases yet named is at once shut off, and the brake is put on by a method hereinafter to be described. Should the engines start the wrong way from the bolts at the top, one of the rams at once brings into action a lever which shuts off the steam and applies the brake instantaneously. This is the only sudden stop, but as little or no momentum has been acquired there will be no appreciable shock or strain attending it.

In applying the brake at very high velocities, caution is of cardinal importance, hence the pneumatic arrangement shown in Fig. 5, Plate XXII., has been introduced. The brake lever is, after being cast loose by the apparatus, buoyed up for a few moments by the inverted air vessel shown in the water tank. As the air escapes from the regulating tap the vessel and lever sink lower and lower, causing the curbs to grip the brake wheel gradually. Directly the indicator arrives at "caution" a larger and still increasing egress of air is brought about by the consecutive lifting of a series of valves, attached by a suitable arrangement to the air-vessel. By the time the air has all escaped, the tank Y^1 has sunk low enough to take water from an adjoining fixed vessel Y^2, the movements of the power arm of the brake lever are each instant thereby increased, the momentum of the drum and other parts is destroyed and the engines brought to rest.

The apparatus is supplied with a couple of alarm gongs, which admonish the engineman whenever he is running too fast beyond any of the points of caution.

The writer concludes by submitting an enumeration of the chief points of this apparatus:—

1.—It prevents a too rapid wind near the top or the bottom.

2.—It obliges the engineman to take the greatest possible care when raising or lowering men, and will take care of them if anything should happen to him.

3.—It stops the descending cage from being dashed on to the bolts of an intermediate inset whenever they are left on by mistake.

4.—It provides an arrangement whereby the banksman, should any emergency arise, is enabled to bring the engines to a stand.

5.—It affords a thorough check upon the engineman during shaft repairs.

6.—It will stop the engine or engines when from any cause they "turn again."

7.—It prevents the engineman from drawing the cage over the pulley by starting the wrong way.

8.—It will bring the engines quietly to a stand should the engineman fall in a fit, or otherwise lose control of them.

9.—It provides a means whereby the colliery engineer can limit the speed.

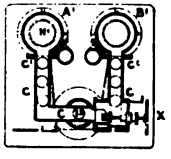
10.—It compels the engineman always to give the strictest attention to every wind, and affords a safeguard against the accidents which sometimes happen when a new or incompetent man takes charge of the engines.

11.—It is always in working order, and does not require to be tested occasionally to see if it will act. Every time the cage descends or ascends the buoys pursue their upward and downward course, ever watchful to avert disaster.

The CHAIRMAN said that everyone would hail with pleasure the introduction of anything that would increase the safety of mines, or minimize the chances of accident to which they were all more or less liable. The question was whether the apparatus which had been explained to them would fulfil those conditions. For his

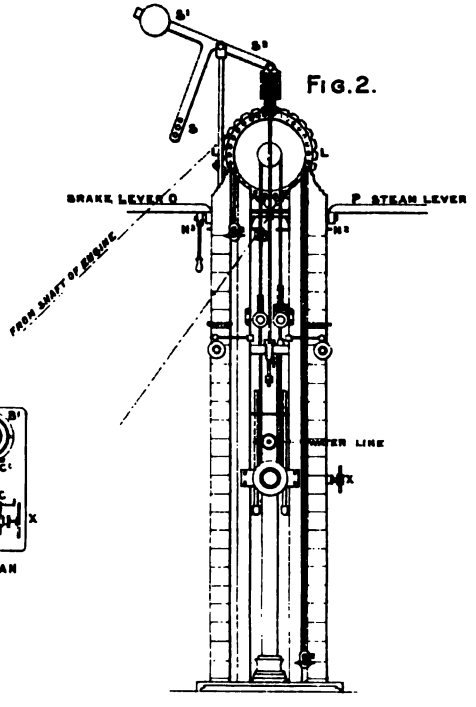
To illustrate Mr William Grimmills Paper on an "Apparatus for the Prevention of Winding & Overwinding Accidents at Collieries and Blast Furnaces".

FIG. 1.



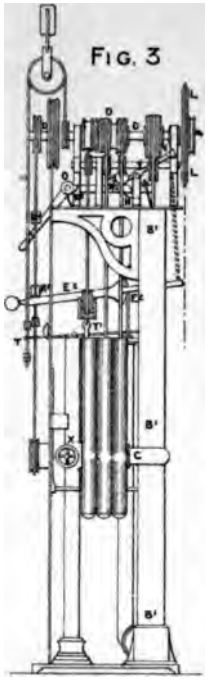
SECTIONAL PLAN

FIG. 2.



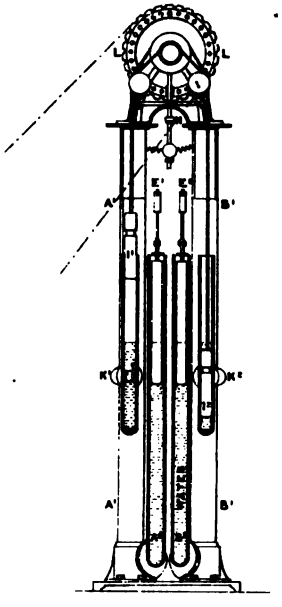
FRONT ELEVATION

FIG. 3



SIDE ELEVATION

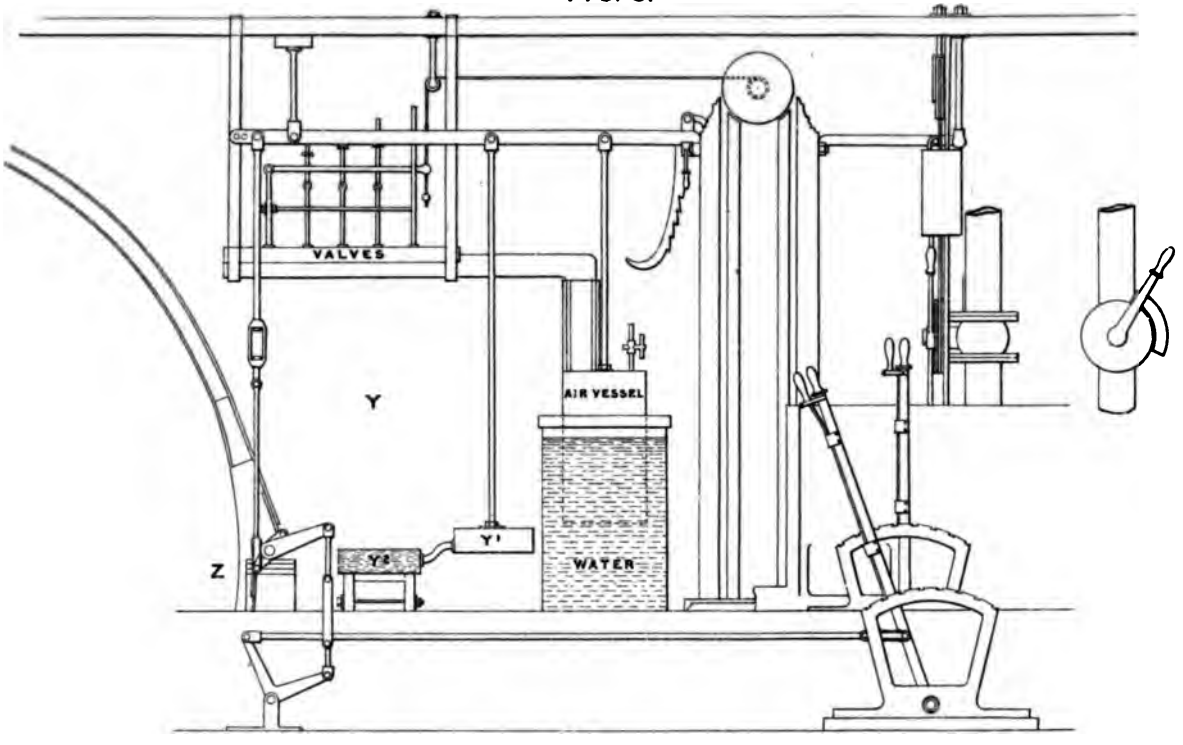
FIG. 4.



SECTION

To illustrate Mr William Grimmills Paper on an "Apparatus for the Prevention of Winding & Overwinding Accidents at Collieries and Blast Furnaces".

FIG. 5.



BRAKE ARRANGEMENT

And.w Reid, Sons & Co. Lithos. Newcastle

part, he ought not to criticize it, because he had not been able to avail himself of the opportunity of seeing it at work. The mechanism appeared to him to be very complicated; still it was a machine which must interest all mining engineers, and from the experience which they had had of existing arrangements he thought they would easily be able to see something in the apparatus which would meet their approval or otherwise.

Mr. A. SOPWITH said he had been able to see this apparatus at Oldbury, and he spent an hour and a half in going into all the points. He was of opinion when he first saw it that it was an excessively complicated machine, and the diagrams certainly make it appear to be such. But after going into the various details, and asking all the questions which occurred to him, he came away with the impression that, so far as the working of the apparatus was concerned, it was a most ingenious arrangement, and he also believed it was a very practical one. It was very difficult to follow the reading of such a paper as had been read; but if any persons liked to go and really study the working of the arrangement, he was quite sure that they would appreciate the ingenuity of the invention. The chairman had drawn an analogy between this apparatus and that of Mr. Younghusband, which came into operation just after the mischief was done. But the very effect of this arrangement was that it did not come into action suddenly. It seemed to him that those who were interested in brakes should at all events go and give some time to this machine, and he really believed that it would lead to a very good discussion if they would examine all the points and see if there were any occasions on which it would not act. He was inclined to think that it was really a practical arrangement. They were very much indebted to the inventor and patentees for the way in which the machine had been brought before them. The paper differed from most of those which are brought forward by interested persons, inasmuch as the principle of the apparatus was, he considered, most novel and original.

Mr. H. W. HUGHES took Mr. Sopwith's view that members should go and see the apparatus. He asked whether it was possible to have diagrams and copies of the paper supplied to them before a discussion took place. He suggested that Mr. Wheeler, who was interested in the patent, should get a machine fixed at some colliery, and that the members should go there and see it at work.

Mr. WHEELER said he should be very pleased to have a machine made and fixed at any colliery where he might be allowed to do so.

Mr. SOPWITH added that there was one point about the machine which was valuable, and that was that if it came into action accidentally at any time, it could do no harm. There would be nothing more than the stopping of the engine. Every point appeared to have been met satisfactorily and in a thoroughly practical way. For instance, if the engine were going quickly, you did not put on the steam brake, and so smash the thing up, but the brake was applied gradually, and without damage.

It was decided to adjourn the discussion upon the paper, and in the meantime the Secretary would forward copies of the paper and diagrams to those members who expressed a wish to have them.

The CHAIRMAN proposed a hearty vote of thanks to Mr. Grimmitt, Mr. Wheeler, and Mr. Matthews, for having brought the apparatus before the Institute, and for the paper read upon the subject.

Mr. PASFIELD seconded the resolution. There was no doubt great ingenuity about the machine, if it would perform what the designer intended it should. The objects aimed at were objects which all would like to see accomplished, and as an engineer he should like to see a practical test of the complete apparatus applied to a winding engine.

The resolution was unanimously carried.

FEDERATED INSTITUTION OF MINING ENGINEERS.

GENERAL MEETING

HELD IN THE ROOMS OF THE INSTITUTION OF CIVIL ENGINEERS, 25, GREAT GEORGE STREET, WESTMINSTER, MAY 28TH, 1891.

MR. T. W. EMBLETON, PRESIDENT, IN THE CHAIR.

The SECRETARY (Mr. M. Walton Brown) reported the proceedings of the Council meeting which had been held that morning, and said that it had been arranged for the next General Meeting to be held in Birmingham, on Tuesday and Wednesday, September 22nd and 23rd. The bye-laws for the future government of the Institution had been passed by the Council, and would be sent to the members in the concluding part of the volume. The Council had recorded a vote of condolence with the family of the late Mr. Marley (the first President of the Institution) and the family of the late Mr. James Willis, H.M. Inspector of Mines.

The SECRETARY then read the Annual Report of the Council as follows :—

REPORT OF COUNCIL.

In presenting their first Report, the Council of the Federated Institution of Mining Engineers congratulates the members upon the formation of an Institution which now embraces four Institutes, viz. :—The Chesterfield and Midland Counties Institution of Engineers, The Midland Institute of Mining, Civil, and Mechanical Engineers, The North of England Institute of Mining and Mechanical Engineers, and the South Staffordshire and East Worcestershire Institute of Mining Engineers.

The Council propose to use every endeavour to extend their bounds, so that the Institution may embrace the whole of the Institutes devoted to the advancement of mining and its allied industries. By this means its influence will be extended, accompanied with increase in the value of the Institution and its publications to the members.

The number of members on the register for the present year is 1,130.

Mr. M. Walton Brown was appointed Secretary to the Institution on the retirement of Professor G. A. Lebour.

The Council have to express their regret at the unexpected decease of their first President, Mr. John Marley, who died shortly after the close of his period of office, and of Mr. James Willis, H.M. Inspector of Mines, and a Member of the Council.

Meetings of the Institution have been held at Sheffield, London, Edinburgh, Nottingham, and Newcastle, and the Council are glad to congratulate the members upon their generally satisfactory attendance, and to express their thanks to the gentlemen who kindly threw open their works to the inspection of the members.

A leading advantage of the Federated Institution is that the members receive the Papers read at the meetings of all of the Federated Institutes; they meet on equal terms at two meetings in each year in the district of each Institute in rotation, and also annually in London.

The members may be congratulated upon the high standard of the Papers which have been contributed for their information, and the Council hopes that the members will continue to send in their contributions as liberally as heretofore. The Papers read during the first year have been as follows:—

FEDERATED INSTITUTION OF MINING ENGINEERS:—

"Presidential Address." By Mr. John Marley.

"The Geology of the Southern Portion of the Yorkshire Coal-Field." By Mr. R. Russell.

"Coal-Getting by Machinery." By Mr. George Blake Walker.

"The Distribution of Electrical Energy over Extended Areas in Mines." By Mr. Albion T. Snell.

"Coal in Kent." By Mr. Wm. Topley.

"The Economical Working of Steam Boilers at Collieries." By Messrs. W. Armstrong, Jun., and W. J. Bird.

CHESTERFIELD AND MIDLAND COUNTIES INSTITUTION OF ENGINEERS:—

"Notes on the Geology of the Manchester Canal." By Mr. C. E. De Rance.

"Presidential Address." By Mr. George Lewis.

"A Recent Boring at Chesterfield with the Diamond Drill." By Mr. G. E. Coke.

"Soar's Patent Coal-Lowering Apparatus." By Mr. Charles Soar.

"President's Address." By Mr. J. P. Jackson.

"Memoir of Joseph Timms."

"Comparative Experiments upon a Capell and a Schiele Fan Working under Similar Conditions." By Mr. Maurice Deacon.

MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS:—

"Report of an Outburst of Gas in the Haigh Moor Seam at Whitwood Collieries." By Mr. W. G. Jackson.

"An Outburst of Gas at Houghton Main Colliery." By Mr. J. Jarratt.

"On Overwinding and its Prevention." By Mr. A. Bertram.

"A Patent Apparatus, Indicator, and Valves for the Automatic Prevention of Overwinding at Mines." By Mr. C. H. Cobbold.

"Notes on the Medium Fan (Patent)." By Mr. Arnold Lupton.

"The Action of Tidal Streams on Metals." By Mr. Thos. Andrews.

"The Stauss System of Colliery Cage Props." By Mr. Edmund B. Clarke.

"On the Difference between the Seams in the Northern and Southern parts of the Yorkshire Coal-Field as shown in some of the Deeper Sinkings." By Mr. John Nevin.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS:—

"Winding, Banking Out, and Screening Plant at East Hetton Colliery." By Mr. S. Tate.

"Obituary Notice of the late M. Théophile Guibal." By Mr. W. Cochrane.

"Improved Coal Screening and Cleaning." By Messrs. T. E. Forster and H. Ayton.

"The Hauraki Gold Mining District (Northern Section), Auckland, New Zealand." By Mr. D. H. Bayldon.

"Ramsay's Patent Improved Levelling Staff for use in Mines." By Mr. W. Ramsay.

"On the Value of Photography to Mining Engineers." By Mr. A. L. Steavenson.

"On the South Durham Salt-Field." By Mr. John Marley.

SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

"Notes on Mining in North Mexico." By Mr. Walter H. Glennie.

"President's Address." By Mr. Henry Lea.

"Notes on Safety-Lamps." By Mr. Herbert W. Hughes.

The PRESIDENT said he must congratulate the Council of the Federation on the large attendance of members at this meeting. He would not trouble them with a very long inaugural address.

The PRESIDENT then delivered his inaugural address as follows:—

PRESIDENT'S INAUGURAL ADDRESS.

I greatly value the high honour conferred upon me by the Council appointing me President of the Federated Institution for the ensuing year, and I hope I shall be able, with the valuable assistance of your Council and that of your energetic Secretary, to conduct the affairs of the Federation to your entire satisfaction, and that the issue of the Transactions will now appear periodically. But I must remind you that without the co-operation of the authors of papers, and those members who take part in the discussions, in returning at once their corrected proofs, that an unavoidable delay must necessarily take place in the printing of each number of the Transactions. A great part of this leeway has been overcome by our indefatigable Secretary, and I hope when the present mass of printing has been overtaken that the Transactions will be issued with great punctuality. But at the same time I must urge the members to return to the Secretary at once all the material for printing. I fully appreciate the honour and duty of occupying the chair in accordance with the wish of the Council. I felt, however, dismayed at the prospect of being called upon to fulfil this day's function—the delivery of an Inaugural Address. And this for more reasons than one. As year by year those lines of thought which usually form the staple of this time-honoured custom, come to be rewoven they are apt to wax threadbare and monotonous. I will try to avoid this. On the present occasion I propose to endeavour to put before you the progress that has been made since 1826, and even before that date, not only in mining but also in other industries. I must in the first place point out that the constant employment of steam, and the improvement of the steam engine, together with the ingenuity of man are the causes of the progress which has taken place during the last sixty years; and there is no doubt that this progress will go on with like, or perhaps accelerated speed for generations. Whoever may see the end of the next half-century will regard the present time as we do that of sixty years ago—as a time of infancy of all the arts and sciences. The age of inventions will never cease.

Let us take a view of the state of agriculture sixty years ago. All the labour on the farm, the reaping of the crops, the management of the dairy was manual labour, and all other operations were performed by men and horses. Let us see how this was carried out. The wheat and other crops were hand-sown. The reaping of the corn was by the sickle; the hay was mown by the scythe; and to enter more minutely into the several processes after the corn was reaped, it was bound in sheaves by men and women as they sheared the corn, and we heard the rhythm of the flail and the buzzing of the winnowing machine. All this is now changed: the music of the flail has ceased, and the busy hum of the shearers in the field is heard no more. The reaping machine has relegated these things to the past, and they are

now obsolete. The corn now-a-days is cut by the reaper, and the sheaves are now bound by it. Corn is now thrashed and the land ploughed by the steam engine. The grass is now mown, spread, and turned, and in many instances stacked by machinery.

If we turn to the dairy, the milk was creamed by hand and made into butter by the same means; the milk had not the assistance of the cow with the iron tail. Now the cream is separated by mechanical power, and the butter also, but I am sorry to say that the assistance of the aforesaid cow is too frequently employed, and much of the so-called butter is a mixture of that which never had any relation to cows' milk.

Let us see how the lathe was worked. The connecting strap passed over a large wheel, which was turned by manual labour, the cutting tool was held by both hands, assisted by the shoulders, and often the tool cut too deep, was wrenched from the hand that held it, possibly breaking through the window opposite. There were no planing machines or the numerous other contrivances now in use. Whereas, at the present time, the lathe is self-acting, and may be adjusted by a lad. If you required a main shaft of an engine, it was made of cast iron, or made of the requisite size by faggoting and welding separate bars of malleable iron together, but even this arrangement was not successful, for the bars frequently separated from each other in a short time. Now, you can have shafts of any size made from a solid mass—thanks to the invention of the steam hammer.

Cranks and wagon wheels were then made of cast iron. Now, by the aid of the shaping machine they are formed from malleable iron or steel, and so it is with many other inventions for the saving of labour.

As to boilers, perhaps none of our members present saw a cast iron boiler working with as much as 10 lbs. to the inch. These were in use during the year 1830. Then came the malleable iron haystack boiler, succeeded by the wagon boiler, the boiler with one or two internal flues, and recently a further invention of making the flues of corrugated iron. The latter forms have effected a great saving in fuel, and no doubt further progress will be made in this respect. Now boilers made of steel are coming into fashion.

With regard to steam engines many years ago there was no condenser. A jet of water was thrown into the cylinder and a slight vacuum was formed, the beam, generally of wood, at the opposite end to the cylinder, was loaded with a piece of cast iron, brought the piston to the top of the cylinder, and thus the work was performed. Other engines had open-topped cylinders and separate condensers. It would be asking your attention too long to enumerate the various modifications of engines from time to time till we arrive at a period when compound and triple cylinders were brought into use.

I may mention that on one occasion when fitting up a high pressure horizontal engine for underground hauling, I was told by a viewer (as we were called in those days), that the load to be hauled, being so heavy, would certainly pull the engine over. However, I persevered with the engine, and the predicted catastrophe did not happen.

As to electricity, it was then a toy; the revolving of a glass cylinder, on which was a piece of silk, produced what was required. When all was in readiness you were placed on a stool with glass legs; you held in your hand a wire in connexion with the machine, you were covered by the electric fluid, and the company amused themselves at your expense by touching you to take a spark from you, and you enjoyed the sensation of being pricked. Or Leyden jars were filled with electricity and discharged—to the great amusement of the bystanders.

What was then a plaything has now become a valuable agent. Continents hold converse with each other, thus, as it were, bringing far countries nearer together, and at the last we are able to talk with each other by means of the telephone; nay, more recently by the under-sea telephone a person sitting in England can hear the music of an opera which is being performed in Paris. Words and messages can be registered and used on any occasion when required—indeed, the electric fluid can be stored and carried from place to place. Already has electricity been employed in lighting towns and buildings. It is in successful use for underground haulage, pumping, and coal-cutting. On short railways it is the motive power. And in a thousand processes it is essentially necessary.

With regard to railways, the rails were first constructed of square pieces of timber, and to remedy the great wear and tear of the wood the next improvement was to nail thin pieces of iron on the surface. (A railway thus constructed was to be seen in the neighbourhood of Gateshead a few years ago.) Afterwards cast iron rails took the place of the above; they were fish-bellied, with square ends. This plan was modified by making the ends of the rails overlap. The next change was to make them of malleable iron, also fish-bellied; these weighed 32 lbs. to the yard. Iron rails of various sections were made, till at last by means of the Bessemer process steel rails, weighing 80 lbs to the yard, were adopted.

At first railway wheels at collieries were of wood (and to prevent shrinkage in summer the wagons were passed through a pond) then of cast iron, and lastly of steel.

Alas for our "Hearts of Oak" which did such service in the wars with France and Spain, under the command of the brave officers and men of that period, they are gone. This is an iron age, and therefore our war vessels are made of iron, or of steel, and many are sheathed in enormously thick armour.

The prediction in 1836 of Dr. Lardner has not been fulfilled. He said: "The distance from London to New York, supposing the uninterrupted voyage were possible, would be about 3,500 miles. Even in average weather the consumption of fuel would be at the rate of the twentieth of a ton per horse-power for 3,500 miles, being more than the total quantity of fuel which the Admiralty steamers are capable of carrying. . . . . It will appear," he further adds, "how little hopes of success can at present attend this project." He deduces from a voyage by steam, from Falmouth to Malta, that the average speed did not exceed 7¼ miles an hour. Again, he says that "the average of 51 voyages made by the Admiralty steamers from

Falmouth to Corfu and back during four years ending June, 1834, was also 7¼ miles an hour. These vessels varied from 350 to 700 tons burthen, the power 100 to 200 horse-power, stowage for coal, 80 to 240 tons." We now know that the doctor's apprehensions have been falsified, and it is needless for me to recapitulate the changes that have been made since the time when the doctor wrote his treatise on the steam engine. He would have been surprised to learn that the distance between Liverpool and New York is performed in less than six days. The doctor recommends that vessels should be built of iron instead of wood, because the former if driven by a storm upon the rocks would only receive a dinge, or perhaps be pierced by a hole equal to the point of rock on which she strikes. If a timber ship strikes, a plank is broken, and a chasm opened in her many times greater than the point of rock!

On the subject of mining I have to say a few words. No pits had guides, and the only method of the descent or ascent of the men was by putting your leg into a loop made in the chain attached to the rope, guiding yourself with your yard stick, or if any examination of the shaft was required you sat upon an —— loop. I must leave out the former distinguishing word, which is pure Saxon. The basket corves hung free in the shaft.

Guides were first used at the collieries of the Duke of Norfolk, at Sheffield Park, and Attercliffe Common, in Yorkshire; the inventor was John Carr, colliery agent to the Duke. The appliance consisted of two guides of wood reaching to a short distance from the midway of the shaft; at meetings there were four guides worked by switches to allow the corves to pass, and below this point two guides again. On the corve reaching the surface a platform was drawn over the mouth of the pit on which the corve was landed. On the bar forming the attachment to the corve were placed three small rollers, two on the front of each side of the guide, and one at the back. Carr obtained a patent for his invention; it is dated, Westminster, the 12th day of August, in the 28th year of the reign of George the Third. The specification was printed at Newcastle by S. Hodgson in 1789. The accompanying drawings were made by John Buddle, Jun.

Many collieries in the various coal-fields were worked by modification of the bord and pillar system. It happened at times that the pillar was too weak to support the superincumbent strata, and if the floor was soft or there was water present, the pillars thrust out the floor to such an extent that the bords were filled up solid and a fresh winning of the pillars had to be made.

Working longwall is now come into use; thereby the circumstances being favourable the coal is got without so much loss, and the system notably safer with regard to the workmen. The ventilation is more simple than in bord and pillar working, and when the roof falls freely, the excavated part is filled up, thus leaving no goaf for the collection of fire-damp. It is also a question whether it is productive of sudden outbursts of gas or otherwise.

The instrument for underground levelling was very primitive; it consisted of a trough 6 or 7 feet long filled with water; two sights were placed, one at each end of

the trough, they passed through a groove and thence downward, so that the lower ends touched the water. The observer then laid himself at full length and looked over the top of the sights at a candle placed on a stick and the comparative heights were measured. Even above ground levelling was not much better. The object rod had a sliding beam, which was lowered or raised according to order; this rod was marked with inches and eighths, the level was then measured from the ground to its centre, and the difference between the height of the level and the object was taken, and the difference was either the fall or the rise of the ground. Notwithstanding these primitive methods many operations were done with considerable accuracy. It was not till Mr. Sopwith invented his "stick" that the present system of taking the fore set and the back set was adopted.

The first attempt to secure the shafts from water was by fixing cribs in the shaft, on which were nailed 3-inch planks, the edges being bevelled according to the radius of the pit. The foundation was oaken cribs well wedged at the back. The next method was to make the tubbing of cast iron, joined together by external flanges and bolts, with a wood crib placed at intervals. This was followed by the mode now in use, both the horizontal and vertical joints are wedged. I have tried successfully, in order to avoid the expense of wedging, another method. The space behind the tubbing was filled with soil, as the building advanced, without ramming. When the work was completed the lower plug holes were bored out, and in every instance the soil was perfectly dry. The length of tubbing was about 70 yards. The same success attended 20 yards of stone tubbing laid in cement, treated in the same way, the examination showed the same result.

For ventilation fans are erected everywhere, and the furnace abandoned. The first fan was erected in Yorkshire, at one of Lord Fitzwilliam's collieries, about the year 1836, by Mr. Biram. Now there are numberless fans at work, each maker boasting that his is the best. Which is really the best will, I hope, be eventually proved when we receive the report of the Fan Committee which will be issued shortly.

Journeying in 1831 by coach to London from Leeds occupied a day, a night, and another part of a day. From Newcastle to Leeds in 1824, took fifteen hours, afterwards eight hours. It was a pleasant journey from Newcastle—breakfast, dinner, and tea. You could see the country and enjoy yourself; there was no hurry in those days. The locomotive engine drove all the coaches off the road, and it takes you to London in less than four hours. The speed was not great at first. Sixty miles an hour was not even dreamed of. In travelling on the Leeds and Selby Railway in 1831 (now the North-Eastern), there was a steep gradient of a few miles before approaching the Crossgates station, and if the morning was dewy or wet the train stopped, the guard opened the carriage doors, and asked the passengers to walk to the top of the incline. I hope I have not wearied my audience with these details.

As to chemistry—what wonderful strides it has made in late years! Would it have been thought possible that chemists would have been able to extract those

beautiful aniline dyes or to produce sugar and scents from such a mineral as coal? Various other discoveries are made—I had almost said daily—for the benefit of all industries.

I hope you will excuse me from alluding to the professions of medicine and surgery. With regard to the former, it was the usual custom long ago to compound a prescription containing often twenty or even sixty ingredients. This was done because it was possible that one of the ingredients might cure the disease. The potion should only be taken on certain days of the moon's age, or on lucky days, or according to the horoscope of the patient. The most singular things were mixed together. On one occasion I heard a surgeon of extensive practice say to his apprentice, "Mister, you had better add to the prescription some oculi cancrium." Up to the year 1815 no qualification was necessary. The Royal College of Physicans was incorporated in the 15th year of King Henry VIII., who "did protect y^{e} science and cunning of physic and surgery." Before this the Bishop of London and the Dean of St. Paul's had the privilege of granting diplomas to exercise the professions of medicine and surgery. The same monarch confirmed to the surgeons of London a charter granted by Edward IV., which united the barbers and surgeons under the title of "Barber Surgeons." This combination was not confined to London, for so late as the year 1742 we find the fraternity at Newcastle-on-Tyne. Here this company was united with the Company of Tallow and Wax Chandlers. Amongst other curious orders are the following:—"No brother shall shave on a Sunday. That no brother shall shave John Robinson till he pays what he owes to John Shafto." Apprentices were not allowed to marry till the expiration of their apprenticeship; if they did they were fined. It was not till the year 1815 that it became illegal to practise without a qualification. Perhaps you have seen a picture representing an amputation of a leg in the olden time. There is the operator sawing away, the learned doctors standing around, looking on with amazement while an assistant is holding a bowl to catch the blood. They do things differently now.

In conclusion, I would address a few words to those who are learning the profession of mining or mechanical engineers. Don't be afraid of work or long hours. Don't spend your time in the office. Go down the pit, or stay in the workshop. "What is worth doing at all is worth doing well." If your opportunities are great, see that you make a good use of them. If your calling is a noble one (and it is a noble one) seek to be worthy of it. If you aspire to a position of eminence, this depends upon the right and earnest use you make of your youth. In a word, as you hope to succeed in life, begin without delay to lay the foundation—be in earnest. If, on the other hand, you are careless and indifferent, you will have to suffer in after life. You have now greater opportunities of learning the details of your profession than all those eminent men who have passed away. In their early days there was no Mining Institute to obtain that information both in theory and practice which is now open to you. And, above all things, consider that the lives of those over whom you may be placed are in your hands. What says the poet?—

"God often hangs great weights on slender wires,
Wraps oaks in acorns, life in viewless germs;
From smallest sparks he kindles greatest fires,
Sends us for wisdom to the ants and worms.
So as we go unthinking on our way
We stir great forces, tread on secret springs,
Lay trains of curse or blessing; day by day
Do deeds, speak words, with hidden sweets or stings,
Fraught with large consequences; mysterious powers
Destined to bear their fruit in other lives than ours."

Sir GEORGE ELLIOT, Bart., M.P., said that when he came into the room he had no idea that he would have the very agreeable duty and pleasure of proposing a vote of thanks to their worthy President for the most interesting address he had just delivered to them. He had known Mr. Embleton a very long time; perhaps no other gentleman present except himself could appreciate the story told in the short narrative of the last sixty years. Nearly the whole of it came within the range of his (Sir George's) own distinct recollection. It was marvellous to witness and to reflect on the progress of great works which had been made during that time. He had often wondered—though he did not know whether the simple observations he had to make would explain—how it happened that, so far as he could judge, everybody seemed to be better off in the world, both pecuniarily, socially, and in every other way which affects human happiness and human nature. It appeared to him to be very much so: when he, with so much pleasure, witnessed that at the collieries he worked at some sixty years ago they could now afford to pay the men better wages. He then worked at a colliery which he now owned—he was going to speak of himself for a little while—and they worked fourteen hours a day. He worked in the pit fourteen hours a day for six years, and then came the great strike of 1831 and 1832, a strike which the President would remember as probably the largest and most virulent strike they had ever had in England—certainly in the coal trade. There was death and bloodshed, and men were hung in chains on Tyneside. And what was the strike for? He was one of the strikers, and it was to get the hours of labour reduced from fourteen to twelve, and they remained at twelve. It was only within the last twenty years—in 1870—that the hours were reduced to fifty-six per week instead of the longer time they worked before; and it was a great pleasure to him to have been instrumental in getting the hours of boys under sixteen reduced from twelve to nine per day. But how did it happen that everybody could afford to live better, to have better clothing, and better everything, although working far less time? That was the question which required an answer, and the way he reasoned it out was this: that one hundred years ago—whatever the population of the world was then—it had to depend upon the

produce of the earth, obtained by the bone and sinew and vigour and strength of man and beast, and when they considered the present population of the world, it might be—though he did not know how—they were accorded a power to be exercised in the production of that which was useful and beneficial to mankind, and were producing every generation a further generation of strength in the form of mechanical appliances to keep pace with the requirements of the increased population. Many might not agree with him, but had we not put an end to famines, and by bringing goods now from one country to another prevented there being scarcity anywhere? And was not this due to the mechanical progress which was being made and was demonstrated to-day? And he specially felt honoured when he learned that Mr. Embleton was their President. It was some time since they worked together, and since then he had seen Mr. Embleton's gallant son go down the pit after an explosion—the explosion at the Oaks Colliery—and he was on the pit heap when he brought the man out alive, a deed for which he ought to have had the Victoria Cross; and he never felt a desire to embrace anyone so much as he did that young man! But they might think he was digressing a little from the subject of the health of their worthy President and their thanks to him for his worthy address. They could see Mr. Embleton was an old gentleman; he had lived through all the period of the changes he had referred to in his address, and they hoped he would still be spared to enjoy every blessing God would endow him with. He (Sir George) had, as they all knew, had something to do with works; and as he was sitting at dinner the previous night with Sir Hussey Vivian, Sir Edward William Watkin (the Chairman of the South Eastern Railway Company), and—they were welcoming Sir Charles Tupper, who was Prime Minister in Canada (a great man both here and in his own country)—they were speaking on this same subject, and they found they were all about the same age, all had laboured very hard, and all had titles conferred upon them by the Queen. And this was open to everyone present, although perhaps they could not all be knighted. But it did happen that they had the privilege of discussing the enormous changes brought about during their time, and he thought it was in the order of things, by the will of the Great Author of all good, that human happiness was going to be from henceforth, as over the last sixty years, immensely increased by such Institutions as this. He had great pleasure in asking them to join him with acclamation in thanking the President for his excellent address, and to suggest that it might be most useful to have it circulated, not merely amongst the members, but generally.

Mr. WM. COCHRANE (Newcastle) said he had great pleasure in seconding the vote of thanks to the President for the trouble he had taken and the time he had devoted to giving them this valuable record of his experience. They were thankful to him, too, for the encouragement he had given the young men to go on to the next term in the history of the progress of mining industry and mechanical engineering, and to do as well as had been done in the past sixty years.

The vote of thanks was carried with enthusiasm.

The PRESIDENT, in reply, said he thanked the members very much for the manner in which they approved of what he had already done. As he said at the beginning of his address, he thought it a most difficult thing to write an inaugural address, for, having to refer to so many subjects, one was apt to run ahead on one subject and leave the others out, and he felt sure he had omitted many things which he might have said with relation to the past years—back to 1826, or even before that—but he thought he had said sufficient to show what progress had been made in the last sixty years. When they saw another half century they would be quite surprised to find what further improvements had been made. As there were many papers to be read that day he would not detain them longer than again to thank them very heartily.

Mr. FOGGIN then read the following paper on "Locked Coil Wire Ropes":—

LOCKED COIL WIRE ROPES.

By William Foggin.

The greatly extended use of wire ropes in recent years, and the important part they play in various industries, has drawn much attention to economical reforms in their manufacture and in their use; and although a great deal has been done in the way of improvements in the appliances on which ropes are used, it is but very recently that any marked improvements have been made in the rope itself, and it is chiefly this latter matter that this paper proposes to deal with.

It has long been felt that a rope, after having performed even what may have been considered satisfactory work, has yet had but little surface in comparison with its weight exposed to the friction incidental to its use, and, consequently, a rope but fractionally reduced in weight is frequently cast aside as comparatively useless, being either full of broken wires, or with the crowns of the wires so worn as to render its further usage unsafe.

Ropes as ordinarily made permit of only one external component wire of each strand being in peripheral working contact with the surfaces over which the ropes run or against which they rub. (Fig. 14, Plate XXIII.) These points of contact become in time abraded and flattened, the rapidity of the abrasion or flattening decreasing as the amount of the abraded portion increases. In many cases, notably where crucible steel wire is employed in ropes, the flattening by percussion hardens the wire and renders it brittle, destroying its usefulness at a very early period, and as every single wire in the rope appears at the surface at regular intervals, it necessarily follows that the strength of the rope becomes most seriously impaired.

It is apparent, then, that when a rope is first put to work, the diminution in strength is rapid, and that by the time the rope has been worn to a fairly smooth state, the strength has so seriously decreased that the wires are unable to stand the strain and break.

It frequently happens also that the wires in the strands at the points where the strands come in contact with each other, get chafed through, or partially through, and as all the wires alternately occupy such position in regular sequence throughout the rope, it therefore follows that every wire of which the rope is composed is equally damaged, and a state of great weakness may exist and yet not be visible from the outside.

It is obvious where ropes have to bend to the curves of wheels or drums over which they have to work, that the outer fibres of each wire, as they accommodate themselves to such curves, are in tension and the inner fibres in compression, while the centre or neutral axis remains unchanged. Consequently, it may be taken that the more flexible a rope (*i.e.* the less resistance it offers in the way of compression and tension in each wire) where it is subjected to much bending in work, the better

will be the results, provided always that such flexibility be not obtained by the use of wire of such fineness that the wearing capacity of the rope is prejudicially affected.

The difficulty of meeting these conditions will be at once seen, for in cases where only small drums and pulleys are admissible, and yet excessive friction has to be encountered, it is obvious that small round wires, such as would be employed in an ordinary rope for such a purpose, would soon get worn through, whilst heavy wires would be speedily fractured owing to the intermittent compression and elongation of their fibres (whilst the rope was at work as already described), which is necessarily greater in large than small wires on a given curve. Obviously, too, a rope which would do admirably well as a fixed rope for aerial tramways, or as cage guides in shafts, where a certain amount of rigidity is advantageous, would be unsuitable for winding, hauling, or transmission of power where flexibility is essential.

LOCKED COIL WIRE ROPES.

To meet the objectionable features presented by the ordinary make of rope, the locked coil wire rope was invented by Messrs. Latch and Batchelor in 1885, and a variety of sections are shown in Figs. 1, 2, 3, 4, 5, 6, 7, and 8, Plate XXIII.

Locked wire ropes are made with a series of coils of wire, one coil spirally wound upon another, the outer of which is composed of suitably-shaped wires illustrated in the foregoing figures, and when closed together interlock and present a structure with uniform wearing surface in which each component wire is held permanently in its proper position even when fractured, whereas in the ordinary construction of wire ropes broken wires commonly turn outwards, thus causing obstructions and sometimes the stripping of strands.

In the locked coil rope the protection afforded to the inside coils by the interlocking outside wires prevents damage arising to them from friction, and as these inside coils are never exposed, and retain the coating of preservative matter with which they are covered in process of manufacture, an element of great safety is always in existence, as they constitute from half to two-thirds of the entire strength of the rope. Take, for example, a 3-inch rope, which is made up as follows:—

				Breaking strains.		
			lbs.		T. c. q. lb.	
Centre coil,	6 round wires,	No. 16, at 85 tons per square inch =	600	each wire =	1 12	0 0
Second coil,	10 „ „	No. 15, „ „	800	„ =	3 11	1 0
Third coil,	20 square wires,	No. 1, 75 „ „	1,050	„ =	8 18	0 15
Fourth coil,	28 „ „	No. 2, „ „	1,000	„ =	12 10	0 0
Outer coil,	33 locked wires	„ „	1,100	„ =	16 14	0 12
			Total,		43 5	1 27

Each series of coils in fact constitutes a perfect rope in itself, and when the outside coil in course of work becomes worn or damaged the inside coils are still available as ropes of smaller diameter or for re-covering with a new layer of interlocking wires, a process which was successfully carried out in the writer's experience,

and the re-covered rope afterwards worked twice as long as any previous rope in the same shaft.

It may be argued that no wires of any shape are so sound and strong as those which are circular in section. Experience has not borne out this theory, as sectional wires stand equally severe tests for torsional tension and elongation in the testing machine. An examination of the wires of one of these ropes is interesting, each wire being beautifully rounded and free from sharp edges. Moreover it may be pointed out that a round wire when exposed to wear rapidly assumes sharp edges, thus ⊃ (Fig. 14, Plate XXIII.), as an inspection of the crowns of the strands and the two points where the strands rub together in any ordinary rope which has been at work a reasonable time will demonstrate.

The density and compactness of a rope made on the locked wire principle has the advantage of not only excluding water and deleterious matter, but of occupying less room, and being lighter, strength for strength, than ropes of any other make, every wire with the exception of the single centre wire being a factor of strength.

For example: a 3-inch circumference locked wire rope weighing 13½ lbs. per fathom equals in strength, metal for metal, ordinary ropes 3½-inch circumference, weighing 18¼ lbs., made entirely with wire, or 15¾ lbs. made with hemp centre core. An illustration (Figs. 16, 17, and 18, Plate XXIV.) is given of the above advantage, at Messrs. Crawshay Brothers, Castle Colliery, Cyfarthfa, where after deciding to draw coals from different levels, two flat ropes, 4 inches by ¼ inch, each weighing 2 tons 6 cwt. 3 qrs., were replaced on the same drum space by round locked wire ropes, 3¼-inches circumference, each weighing 1 ton 7 cwt.

It was proved at the Vale Colliery, Nova Scotia, that a saving of 50 per cent. was effected in the wear on sheaves and pulleys, and a consequent economy in driving power by using these smooth-surfaced ropes.

The various coils of wire of which these ropes are composed are laid in varying directions, and in such a manner that the area of metal wound in the one direction shall be equal in strength to that wound in the opposite direction. It is thus apparent that the rope is free from all tendency to "spin," which to those who have experienced the sensation of being lowered in a bucket is a quality to be fully appreciated. But a still more important advantage is a result of the arranging of the various coils so as to balance and counteract each other in any tendency to spring back and uncoil. Should the interior wires from any cause whatever be broken or lose their strength, the balancing of the respective areas would be destroyed, and as a consequence the outside layer of interlocking wires would have the greatest amount of power, and in untwisting, as they would do, make the rope bulge up; thus in the most unmistakable manner attention would be drawn to the failing and constitute a great safeguard, for, as already stated, a third or more of the entire strength of the rope is carried on the outside coil.

But, as explained, seeing the wear of the rope is on the outside and not on the inside, the chances of the inside failing are extremely remote, provided good wire is used.

So marked a feature is this "balancing" that in the process of manufacture great restraining force is requisite to keep the inside coils from kinking, but directly the outside coil is laid on, the completed rope lies perfectly dead. In stripping ropes after four years' constant work the inside coils have been found full of life and tendency to kink, thus proving that the wire had lost little or none of its quality or vitality.

A further advantage of the non-spinning quality is that the torsional strain which so detrimentally takes place in the wire of ordinary ropes in working is entirely eliminated. Perfectly new locked wire ropes have been unwound for the first time down 250 fathoms of shaft without making a single turn.

In the earlier stages of the manufacture of these ropes great difficulty was experienced in getting the wire drawn of uniform temper, the manufacture being a novel one, but subsequent experience has enabled the wire-drawers to overcome that trouble, and the wire now produced is of the most satisfactory character, and is drawn with an amazing degree of accuracy, as little variation as ·004 of an inch occurring in pieces 1,000 yards long.

As is well known wire hardens in work, and it is therefore found expedient (seeing there is not that rapid wear which takes place in ordinary ropes) to draw the wire mild, and let its strength increase in work, and thus add to the longevity of the rope. For example, say a quality of steel is used which by severe "holing" is brought to a strength of 125 tons per square inch, the same quality of steel would be used, but by a less severe process in drawing would only be brought up to say 110 tons per square inch, and the remaining 15 tons would be accumulated by the wire whilst the rope was at work, and so it happens that a locked wire rope may possibly give as high a breaking strain after a long course of wear as when new. The harder a wire is drawn in the first place the more unreliable it becomes. A non-crucible steel is often drawn to the same strength as would be given by a crucible steel simply by severe holing, but not having the inherent qualities of crucible steel it consequently makes an untrustworthy wire.

In locked wire ropes the shape of the wire to a great extent determines their flexibility, for it is possible to use a wire of great depth, as in Figs. 5, 6, and 7, Plate XXIII, and though heavy per fathom as compared with round wire, which would be used to produce a rope of similar size, yet form a marvellously flexible rope, for in bending, the wire (which is spirally wound into the rope) bends across its thin and least resisting part. A round wire if flattened out would obviously offer less resistance than when in its cylindrical form.

All the wires of which the locked wire ropes are constructed, except the solitary one in the centre, which is made of annealed wire, take an equal share of strain, the variation of the spiral lays in the various coils of which the rope is composed being regulated in respect to the altering circumferences. Sometimes, however, a rather longer or disproportionate lay is given to the external coil of wires in order that the outside may bear the greatest strains and thus afford additional security.

It will be observed that as the wires on the outside of the rope continue on the outside throughout its entire length, the wear on them is even, and thus in bending they have not the tendency to break when worn, which is observable in ordinary ropes. A wire worn down to an even thickness throughout its entire length will bend more readily than if worn only at various points.

Before concluding this survey of locked wire ropes it might be well to mention that there are a great number of these ropes used both in this country and abroad, some of them over 17 tons in weight, which are doing exceptionally good work, having already, in many instances, run two to three times as long as any previous ropes working under precisely similar conditions, and being still in excellent order. An instance in point is at Walker Colliery (Fig. 15, Plate XXIV.), where a locked coil winding rope, 500 yards long by 2¾ inches circumference, worked in the peculiar lead illustrated twice as long as any previous rope, and three times as long as others. This rope was damaged through the cage leaving the guides, and it was thought prudent to replace it. For the last thirteen months it has been working on a heavy incline between the colliery and the shipping staith, carrying six 4-ton wagons per load, and still appears quite good.

Again, at St. Hilda's Colliery, South Shields, a locked coil rope, 2¾ inches circumference, worked more than four times as long as any of the previous ordinary ropes at the same work.

The author has authenticated numbers of similar records in favour of these ropes, which might be quoted, were it not that the repetition might be thought somewhat tedious.

FLATTENED STRANDED ROPES.

The inventors of the locked wire rope have recently patented what they term a flattened stranded rope. (Figs. 9, 10, 11, 12, and 13, Plate XXIII.)

This rope, instead of being made up of strands of circular form in cross section is constructed with strands, each of which has one or more flattened surfaces, so that one flattened surface is exposed on the outside of the full length of the rope, with the result that a plurality of wires in each strand must at all times take the wear instead of having only one external wire in peripheral working in each strand as is the case with ropes of ordinary construction (Fig. 14, Plate XXIII.)

As already pointed out, until a considerable diminution of strength has taken place in an ordinary rope, the friction is taken in a very marked manner upon the crown of the one wire nearest the periphery of the rope in each strand; and in cases where small wire is used it is rapidly worn through, whilst heavier wire fractures where the abrasion has taken place.

Owing to the number of wires that are at all times exposed for wear in a flattened stranded rope for a considerable distance along their respective length, a smooth or comparatively smooth surface is presented even whilst new, and the wear consequently being light upon any one individual wire, it is possible to use wires of a very much smaller gauge than could be otherwise successfully employed.

Federated Institution of Mining Engineers
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To illustrate Mr. William Foggin's paper on "Locked Coil Wire Ropes."

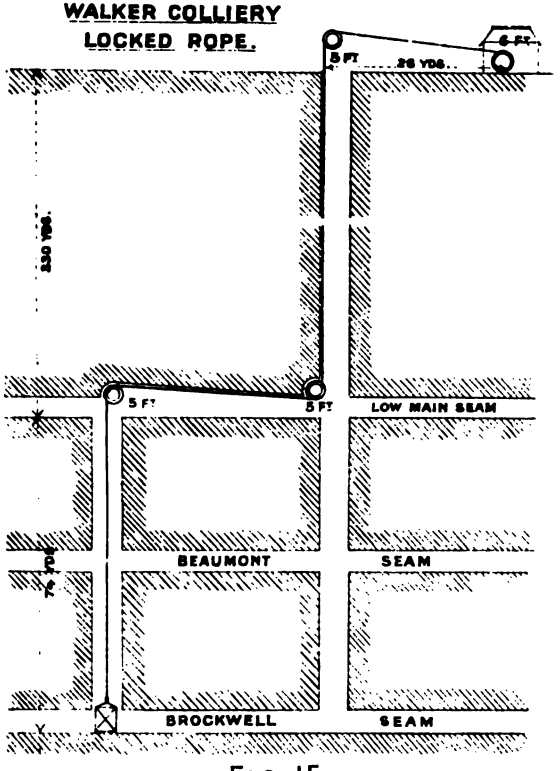


FIG. 15.

PLAN OF ALTERATION TO CASTLE PIT WINDING DRUMS TO WORK THE 9FT & 4FT LANDING WITH "LOCKED WIRE ROPES" IN PLACE OF FLAT ROPES.

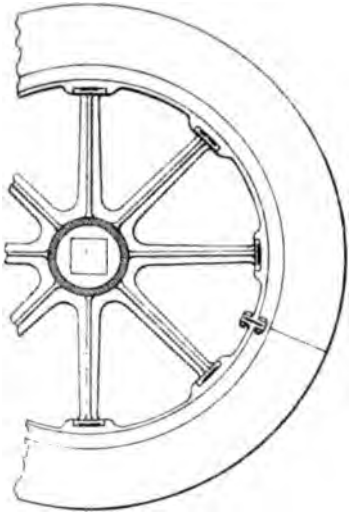
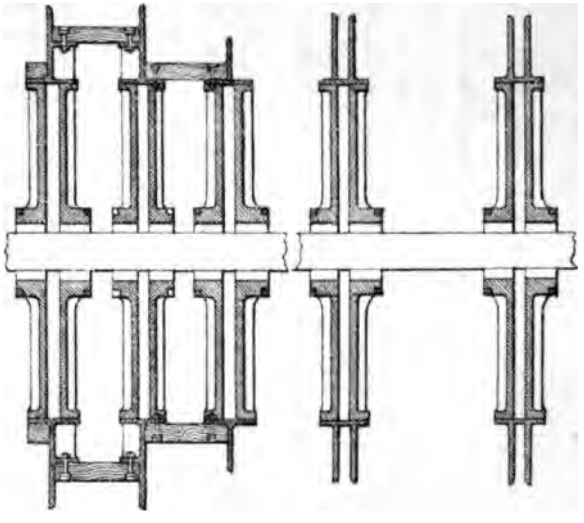


FIG. 16



NEW ARRANGEMENT.
FIG. 17

OLD ARRANGEMENT.
FIG. 18.

Mr. FOGGIN said that referred to the old style of rope.

Mr. BRECKON—But the question raised is, "Is crucible steel inferior?" There is no doubt that steel manufactured in the crucible is as pliable as that made by any other method, and the point was that there was nothing in the manufacture which caused it to be inferior.

Mr. FOGGIN repeated that his remarks only applied to effects produced in ropes in course of use.

A vote of thanks, proposed by Mr. W. COCHRANE, and supported by Mr. A. L. STEAVENSON, was then unanimously accorded to Mr. Foggin.

After a short adjournment for luncheon, Mr. G. B. WALKER read his "Notes on the Coal-fields of New South Wales."

NOTES ON THE COAL-FIELDS OF NEW SOUTH WALES.*

By George Blake Walker, F.G.S., Assoc. Mem. Inst. C.E.

The rapid growth of the Australian coal trade during the last ten years, and the more intimate connexion which improved means of communication have established between that great dependency and the mother country, are in themselves sufficient reasons for bringing some particulars respecting the Australian coal-fields under the notice of the Federated Institution of Mining Engineers; and the subject has this further importance for English mining engineers that it may fall to the lot of some of the members of the Institution to be under the necessity of taking a personal interest in mining matters in that distant land. But, apart from such considerations, the subject is one which is full of general and scientific interest.

During a recent visit to Australia, the writer was enabled to acquire some little information respecting the coal-fields and collieries of New South Wales, both from personal observation and from conversation with Australian mining engineers with whom he came in contact. He is, however, indebted for many of the statistics and facts stated in the following paper to the Blue Books issued by the Department of Mines, Sydney.†

The mineral resources of Australia are as yet only partially explored, but so far as coal is concerned it is pretty well ascertained that the principal coal-bearing strata lie within the colony of New South Wales. Those of Queensland and Western Australia are as yet undeveloped, and no coal of Carboniferous age exists in Victoria or South Australia. The possession of inexhaustible supplies of coal must have a most important bearing on the future of the colony of New South Wales, and must make it the principal seat of the manufacturing industries of the continent. Being adjacent to the coast, the coal-fields can be developed readily at a number of points, and an extraordinarily rapid expansion may be looked for.

It may be well to preface a more particular description of the Coal-measures of New South Wales by a glance at the general, physical, and geological structure of the colony.

Australia possesses only one considerable range of mountains, which traverses the continent from north to south at a comparatively short distance from its eastern shores. It maintains a distance of from 30 to 135 miles from the coast, and attains its greatest elevation at Mount Kosciusko, on the border line between Victoria and New South Wales, that peak rising to an elevation of 7,176 feet. In some parts the

* These notes have been written at very short notice, and under considerable difficulties owing to pressure of work. The writer, therefore, asks indulgence for any errors the paper may contain.

† "The Mineral Products of New South Wales," by Harrie Wood, Under-Secretary for Mines. "Notes on the Geology of New South Wales," by C. S. Wilkinson, F.G.S., Geological Surveyor. "Description of the Coal Seams worked in New South Wales," by John Mackenzie, F.G.S., Examiner of Coal-fields. "Annual Reports, 1887, 1888, 1889," and "Reports of Commissions," etc.

crest of the range extends into considerable table lands. Several lateral ranges branch from it, the principal being that which separates the drainage areas of the Darling and Lachlan Rivers.

The only great river system, that of the Murray, rises in the highest part of the range already mentioned, and flows westward to the South Australian border, and then southward into the Southern Ocean. Its great tributaries—the Murrumbidgee, the Lachlan, and the Darling—rise in the same range at points farther to the north, and flow through extensive prairie lands—the great grazing pastures of the colony. Four-fifths of the area of New South Wales is in the basin of the Murray and its tributaries.

Rocks of Silurian age occupy a considerable portion of the area of New South Wales. In many parts they contain valuable deposits of silver. They are rich in trilobites, molluscs, and corals, and there are some important beds of limestone.

The Devonian measures are chiefly developed in the north of the colony. A section of 10,000 feet of strata has been measured near Rydal, and detached patches are found over a large part of the surface of the country.

Next in order are the Carboniferous strata, with which we have chiefly to do, but before describing these beds it may be well to mention very briefly the strata of later date. One of the most important of these formations is the Hawkesbury and Wianamatta series. The Hawkesbury series, of which the beds in the country round, and north and south of Sydney, are composed, has a thickness, as far as has yet been observed, of about 1,000 feet, and immediately overlies the Coal-measures. These beds are of doubtful age, and afford evidence of glacial action having been concerned in their deposition. At different levels in the series there are thin beds of shale, and the sandstones immediately above these shale beds frequently enclose angular boulders of all sizes up to 20 feet or more in diameter. These peculiar and characteristic beds give the keynote to the scenery about Sydney, and the marvellously beautiful inlets of Port Jackson, the so-called Hawkesbury River, and Port Hacking. The formation varies from a strong hard gritstone to a soft sand, and yields easily in parts to the wasting effects of weather and water. Hence it consists of a rugged country of high ridges separated by deep gullies, into the lower of which the sea penetrates by long winding arms which constitute the harbours already mentioned. Some idea of the surface features, though an imperfect one, may be gained by looking at a large-scale map of the country embraced within the limits of this formation ; and at no very distant date the immense value of these reaches of deep water, opening up the underlying coal-field in every part, will be more apparent then than at present.

The Hawkesbury formation, seems to be an accumulation of drifted glacial detritus (exposed during a period of upheaval to the wasting influence both of aqueous and aërial denudation) in a basin-like hollow formed by the underlying Coal-measures. This is now the general opinion of the best Australian geologists, even if it cannot yet be stated as a finally-proved and ascertained fact. The only

questions which are in dispute are the actual thickness of the Hawkesbury sandstones, and the extent to which the underlying Coal-measures may be denuded. Of course, on these two questions depend the practical ones: At what depth will the Coal-measures be reached? and are the uppermost seams present or wanting? We shall see presently what progress has been made in ascertaining these facts.

Some doubt whether the Coal-measures of Australia belong to precisely the same geological period as those of Europe and America. It is necessary to be cautious in applying the facts and ideas gathered from an examination of the strata of the northern hemisphere to those of the southern, and although there may be, and certainly is, a certain amount of parallelism between the two, we must be on our guard against attempting absolutely to identify them. Dr. James R. M. Robertson, of Sydney, who has examined most of the coal-fields of the east, including those of Borneo, thinks the New South Wales Coal-measures are probably synchronous with the Rhætic and Permian periods of European geology; but whether this is the case or not, the Coal-measures occupy a similar relative position with regard to other formations as that occupied by the Carboniferous strata of Europe and America.

We need not stay to treat of the more recent geological formations, as these do not make a very great show in the eastern part of the colony, though the wide prairies in the west are alluvial plains of recent geological date.

Coming now to consider the coal-fields from the point of view of the mining engineer we find the coal seams cropping all round the basin, indicated on the map (Fig. 1, Plate XXVI.), from Port Stephen in the north to Jervis Bay in the south. Naturally, the coal has been chiefly opened up where it has been made accessible either by its proximity to the sea-board or where the outcrop has been cut by lines of railway. At several points the coal was observed in the cliffs on the seashore, and it was at these points that mining operations were first commenced. At the mouth of the River Hunter (the most important river flowing eastward from the coast range) a seam of coal 4 feet in thickness was discovered at the beginning of the century, and was worked by convict labour under the hill which rises behind the present town of Newcastle. At some subsequent time bores were put down to ascertain what other seams existed, and at a moderate depth a magnificent seam of coal upwards of 20 feet thick was struck, which has preserved to the present day the name of the Borehole Seam, with the alternative denomination of the Wallsend Seam. The discovery of this magnificent bed of coal at once induced the commencement of mining operations on a commercial scale, and the first steps were taken by such companies as the Australian Agricultural and the Scottish Agricultural Companies, which had been already constituted to develop the agricultural resources of the Hunter Valley. We cannot now stop to follow the history of the development of Newcastle, and its growth from small beginnings to its present mighty export trade. We shall touch upon this in a later part of the paper, but will ask you to carry your eyes to a point 100 miles south of the mouth of the Hunter, in the region

known as the Illawarra district, where fine seams of coal were observed by Captain Cook in the sea cliffs, and caused him to give the name "Coal Cliff" to that part of the coast.

It was not at first supposed that these two coal-fields had any connexion with one another. They were thought to be quite distinct. But as the railways have been pushed into the interior of the country, coal seams have been met with cropping out at various points; and as the geological structure began to be worked out, it was found that these outcrops were pretty continuous, forming a semi-circular chain between the two points, Port Stephen and Jervis Bay, already mentioned. The question then, of course, immediately presented itself whether these outcrops did not imply a continuous concealed coal-field extending under the whole of the intervening area. (Fig. 2, Plate XXVI.)

For many years mining operations were confined to the parts adjacent to the outcrops; but as the colony increased in wealth, and the coal trade developed by leaps and bounds, the question of proving coal at points nearer to Sydney, the great centre of trade, received more and more attention. The first explorations were in the southern district, and the results confirmed the conclusions based on the foregoing hypothesis.

In 1887, a borehole was put down at Holt-Sutherland, 16½ miles from Sydney. The strata passed through were found to consist of:—

	Ft.	In.	Ft.	In.
Hawkesbury sandstones	653	6		
Shales, sandstones and conglomerates (the upper 314 feet consisting chiefly of chocolate-coloured ferruginous shales)	1,573	3		
			2,226	9
Upper seam of coal	4	2		
Shales, sandstone and conglomerate	65	0		
Lower seam of coal	5	3		
Black shaly sandstone	5	11		
			80	4
Total			2,307	1

These seams are evidently a continuation of the Coal Cliff or Illawarra Seams.

Another important borehole has been put down at Liverpool, on the main southern line of railway, and the results proved at this point correspond generally with those obtained at Holt-Sutherland, these two places being approximately on the same horizon. At Narrabeen, north of Sydney Harbour, and near the coast, another borehole has been put down, which has raised hopes that the coal-bearing beds under Sydney Harbour will not be nearly so deep as was concluded from the dip of the strata at Holt-Sutherland. Here certain so-called chocolate shales were struck at a depth of 380 feet, and, judging by analogy from the Holt-Sutherland and Liverpool bores, the horizon of the uppermost seams at the Narrabeen bore should be approximately at a depth of 2,100 to 2,300 feet. This result was

somewhat of a surprise, as the dip of the Bulli Seam, from its outcrop at Coal Cliff to its position at Holt-Sutherland, gave an average dip of about 145 feet per mile in a northerly direction. Had this dip continued to Narrabeen, the Bulli Seam would have been over 5,000 feet deep, whereas it is now calculated that it is only somewhat over 2,000 feet deep. The dip of the measures between these two points must, therefore, have considerably decreased, and the beds must be almost horizontal.

If the opinion be adopted of Mr. Mackenzie, the Chief Examiner of Coal-fields, the uppermost bed in the Newcastle series, which comes to the surface at Catherine Hill Bay, and is worked at the Wallarah Colliery, is identical with the Bulli Seam of the Southern district. That seam has a dip to the south of about 113 feet per mile, which should give this seam at Narrabeen a depth of 4,600 feet. If, however, the dip has become less on approaching the bottom of the basin, as has been already assumed in the case of the Bulli Seam, we shall have to suppose that between two points, such as Holt-Sutherland and the Hawkesbury, the inclination becomes so slight as to approach the horizontal, in which case the valuable steam coal seam, which crops out at Coal Cliff on the south, and at Catherine Hill Bay on the north, will underlie the surface at Narrabeen, at a depth of some 2,000 to 2,500 feet. (See Fig. 2, Plate XXVI.) Between Narrabeen and Sydney there is a slight westerly dip which would, of course, make the seam somewhat deeper at Sydney itself, and the Sydney and Port Hacking Syndicate are now putting down a borehole at Sydney, which has already reached a depth of 2,300 feet, and is expected to touch the Coal-measures at 2,700 feet.

This practically comprises all that is at present known to justify the belief that workable coal underlies the area overlaid by the Hawkesbury sandstone, and it remains for further explorations to set the matter finally at rest.

The portion of the concealed coal-field lying between the points mentioned and the Blue Mountains is as yet quite unproved, but the foregoing facts would rather imply the existence of a N.W. to S.E. axis, with the maximum depression in the neighbourhood of Richmond. The beds reappear on the western slopes of the Blue Mountains.

Detached coal-fields—at present of secondary importance—are met with at Dubbo, Narrabri, and on the Clarence River.

It will now be convenient to deal with the three principal mining districts more particularly; and, taking them in the order of importance, the Newcastle district must be taken first.

Newcastle District.

In the Newcastle Coal-field there are five groups of measures which may be said to contain coal. The lowest of these, the Stroud series, seems to be not unlike the lower Coal-measures of this country, containing gritty sandstones, in which occur the remains of fossil plants, with few and thin seams of coal. They do not comprise, however, as far as at present known, any workable bed.

Above the Stroud series we meet with a group of strata, in which remarkably thick beds of coarse conglomerate are met with; and at Greta, 33 miles north-west

of Newcastle, a seam of remarkable thickness and purity comes to the surface. It has been won and worked, but within the area which has been explored it presents some remarkable variations. At the outcrop at Anvil Creek Colliery, it has the following section :—

Roof conglomerate and sandstone, full of Palæozoic fossils, *e.g.*, Conularia, Orthoceras, Productus, Spiriferus, Inoceramus, Crinoids, etc.

	Coal. Ft.	In.	Bands. Ft.	In.	Ft.	In.
Coal	2	6				
Indurated clay			0	3½		
Coal	3	3				
Indurated clay			0	2		
Coal	1	6				
Stone band			0	3		
Coal	0	6				
Stone band			0	1		
Coal	6	0				
Total thickness worked ...	13	9	0	9½	14	6½

Below this, and separated from it by 16 feet of fire-clay and shale, there is 4 feet 2 inches more of coal. The dip is in a westerly direction, about 1 in 9.

The rapid variation in Australian coal seams is nowhere more marked than in the very different section which we find about half a mile from Anvil Creek, at the outcrop of the same seam on the Greta Company's royalty. Here the lowest stone band, which at Anvil Creek was only 1 inch in thickness, has become 4 feet 4 inches, the 16-feet stratum of fire-clay and shale has become reduced to 1 foot 6 inches, and towards the top of the seam a valuable bed of cannel coal 1 foot 2 inches in thickness has made its appearance.

The total thickness of the seam is 26 feet, of which 20 feet is coal. The section in the shaft of the Greta Colliery, half a mile south of last section, is 16 feet 2 inches, made up as follows :—

	Coal. Ft.	In.	Bands. Ft.	In.	Ft.	In.
Coal	1	9				
Indurated clay			0	4		
Coal	0	10				
Indurated clay			0	2		
Coal	4	8				
Black shale			0	3		
Indurated clay			0	4		
Coal	3	10				
Black shale			0	6		
Coal	3	6				
Total thickness worked ...	14	7	1	7	16	2

Both roof and floor consist of conglomerate. The dip is 1 in 6 to the west.

At Singleton Colliery a seam, supposed to be the same as that at Greta, and

27 feet 8½ inches thick, consists of nearly equal quantities of bands of clay and coal, the greatest thickness of coal being 2 feet 2 inches. At the Lecohfield Colliery the Greta Seam appears to be divided into two 6-feet beds, neither of which are of as good quality as the seam at Greta. There are one or two other seams in the Greta group, but they are not worked at present.

In the neighbourhood of Maitland the Greta Seam is brought to the surface by an upheaval of trachyte, which forms an anticlinal, the seam dipping both east and west. Here the seam is much split up, but at the East Greta Colliery a good workable seam is being opened out. I am not able to give the precise section of this.

Between the Greta and the Newcastle series lie the Tomago or Rathluba measures. At Rathluba Colliery a seam about 6 feet thick is worked, though the upper 18 inches is left for a roof. This seam produces a good serviceable steam coal, but the proportion of ash is 25 per cent.

At Woodford Colliery, two seams, one 3 feet in thickness and a lower one 8 feet 10 inches thick, have been won, but the inferior quality of the coal has caused operations to be abandoned.

We now come to the most important collieries, all of which are working the so-called Borehole Seam of Newcastle. Like all the other Australian seams with which I am acquainted, the section of this seam is exceedingly variable, the greatest thickness being at Newcastle itself, where the following section has been proved :—

	Coal. Ft.	In.	Bands. Ft.	In.	Ft.	In.
Roof brown shale—						
Coal	6	7¼				
Band			0	0½		
Coal	6	8¾				
"Jerry" or band			1	6½		
Coal	7	1				
Total thickness of seam...	20	5	1	7	22	0

The section I myself took when at the Australian Company's Sea Colliery was as follows :—

	Coal. Ft.	In.	Bands. Ft.	In.	Ft.	In.
Bright bituminous coal	3	8½				
Band			0	1		
Bright bituminous coal	3	7				
Band			0	0¼		
Bright bituminous coal	2	1				
"Morgan" (bastard fire-clay) ...			0	7		
Bright bituminous coal	0	11				
Band			0	1½		
Bright bituminous coal	1	1				
"Jerry" or band			1	10		
Bright bituminous coal	3	0½				
Inferior coal and shale	1	9				
Total thickness of seam	16	2	2	7¾	18	9¾

At Waratah, a little west of Newcastle, the bottom 1 foot 8 inches of the seam is separated from the upper 10 feet by 4 feet of fire-clay, while at another point the lower part of the seam has altogether disappeared, and 8 feet 11 inches remains as the seam. The section, however, rapidly varies from point to point. At Lambton Colliery the section is 9 feet 3 inches, with five bands varying from 3 inches to one-eighth of an inch in thickness. At the Newcastle Wallsend Colliery, where the coal is of very good quality, the section is somewhat similar, having a total of 7 feet 6 inches, and in another part of the same field 9 feet 3½ inches. At the Co-operative Colliery the section is 9 feet. At the Duckenfield Colliery it is 10 feet.

As will be easily gathered from the very varying sections already given, it will be realized that it was a somewhat risky business to purchase mineral properties and sink expensive shafts to prove this seam on the dip. It is, therefore, satisfactory to find that the seam has maintained a fair section almost up to the shores of Lake Macquarie, and some of the largest and most modern collieries are sunk not far from that lake, including Burwood, Redhead, Durham, etc. The relative positions of these collieries will be seen from the map. (Plate XXVII.) Farther to the west, however, particularly at the Northumberland Colliery, the Borehole Seam appears to be deteriorating, but other seams, and particularly the Yard Seam, are here found in increased thickness. Dr. Robertson says of this seam: "The excellence of the Borehole Coal Seam consists in its purity and the amount of gas it yields. It is an excellent household coal, and though not a true steam coal is a free burning fuel, and adapted for steamers when steam is quickly required, rather than economy. It will compare favourably with any known coal seam for general usefulness."

About 100 to 120 feet above the Borehole Seam is the Yard Coal. This is the first seam which was worked at Newcastle. As far as can be ascertained it is a portion of this seam which has thickened out, which is worked at the Monkwearmouth Colliery, where it is upwards of 6 feet thick. In the recent sinkings at South Burwood and Redhead there is 5 feet of coal quite equal in quality to that of the Borehole Seam. Above the Yard Coal is the Diamond or Dirty Seam. In some localities this is of fair quality. Ascending we have the Victoria, the Australasian, and the Great Northern Seams. The uppermost is a splint coal of fairly good quality for steam raising purposes, but commanding a less price than good Borehole Coal.

The uppermost group (if, indeed, it is properly divisible from the Newcastle series) is known as the Wallarah beds. This is destined to be a very important group in the future, and comprises several good seams; the topmost seam being 8 feet thick; the second seam 14 feet, besides one or two others. The 8 feet seam is perfectly clean from top to bottom, and is worked with an ease which I have never seen equalled, as the coal comes down in large blocks without any difficulty, and makes hardly any small. The Wallarah Coal Company ship their coal not at Newcastle, as is the case with all the other collieries, but at Catherine Hill Bay, where they have a fine harbour and jetty, the mine being about a mile and a half

distant. This colliery belongs to an English company, consisting principally of the directors of the London and North Western Railway Company, and is under the able management of Mr. T. Parton, a Staffordshire mining engineer. I have no doubt that it has a great future before it.

It is this group of seams, and especially the character of the uppermost, which has suggested the possibility of its being the same as the Bulli Seam of the Illawarra district, a theory which is somewhat strengthened by the presence of the 14-feet seam a short distance below. South of Wallarah we encounter a swampy district, to a large extent covered by the Tuggerah Lakes and primeval bush. Boreholes have, however, been put down at Wyong, and somewhat farther to the south, with the following result:—At a depth of 535 feet a seam 5 feet thick was passed through; at 650 feet, a second seam 8 feet thick; and at 770 a seam 12 feet thick were intersected. These are supposed to be the same as the Wallarah Seams.

Illawarra District.

As already stated, the coal seams of the Illawarra group make their appearance in the cliffs by the seashore about forty miles south of Sydney, and are worked at this point by the Coal Cliff Company. The No. 1, or uppermost seam (usually called the Bulli), is here from 5 to 6 feet thick, and of excellent quality, without bands. South of the Coal Cliff property the coal-field is much disturbed by whinstone dykes, and the North Illawarra Coal Mining Company has expended a large amount of capital in developing this seam, with but poor results so far as profit is concerned. This disturbance of the measures continues till Bulli is reached, where the No. 1 Seam is from 7 feet to 8 feet thick, and the same section applies to the Bellambi and South Bulli Collieries. Trap dykes are still met with, but are less hurtful than in the North Illawarra field. In the Corrimal, Mount Pleasant, Mount Keira, and Mount Kembla coal-fields the Bulli Seam attains its best quality. Commencing at Corrimal with a thickness of 8 feet, it gradually gets thinner till at Mount Kembla it is 6 feet. The region embraced by these collieries and that lying behind them will probably be the great producing area of the southern district. At Mount Keira the writer took a number of sections, in all of which the coal was perfectly free from bands and of excellent quality, though slightly variable in bituminous character, in various parts. The southern coal is considered to be better suited for ocean steamers than the Newcastle coal, but it hardly commands as good a price as the latter.

In the southern part of the Mount Kembla Company's field a change takes place in the character of the beds, and the trap dykes again put in their baneful appearance. Hence a large area of coal-bearing strata is rendered valueless.

An important winning of the Bulli Seam has been made within the last few years by the Metropolitan Coal Company of Sydney at their large new colliery at Helensburgh, and reached the coal at a depth of 340 yards. Here the coal seam is of very good quality, and has the following section, as taken for me by Mr. Pringle:—

	Ft.	In.	Ft.	In.
Grey shale top			14	0
Shale			0	5
Top coal	6	3		
Soft coal (suitable for holing)	0	3		
Dirt parting ... ... ¼ in. to ¾				
Bottom coal (hardly as good as top coal)	2	6		
Portion worked	9	0		
Parting				
Seat coal (not worked)	2	4		

The sections given in the Annual Report of the Mines Department are somewhat different, and show how variable even this—the most constant of Australian seams—is. The following are two sections, one at the shaft, and the other 200 yards from it. In the section near the shaft the inferior seat coal is not distinguished from the saleable bottom coal, and the top coal is 7 feet, as against 5 feet 10 inches.

NEAR SHAFT.		Ft.	In.
Roof—Hard grey shale.			
Coarse coal ...	A	0	10
Coal	B	7	0
Band		0	1½
Coal ...	C and D	4	5½
Floor—Black shale.			
Total ...		12	5

200 YARDS FROM SHAFT.		Ft.	In.
Roof—Hard grey shale.			
Soft shale		0	5
Coarse coal and bands	A	0	10
Coal	B	5	10
Stone band		0	1½
Coal	C	1	5
Parting		0	0½
Coal	D	2	7
Floor—Black shale.			
Total ...		10	9½

The following analyses have been made by Mr. Mingaye, of coal taken from the upper, middle, and lower part of the seam :—

Splint Coal, A on sections.

Moisture	0·83	Sulphur, 0·562 per cent.
Volatile hydro-carbons	17·47	Specific gravity, 1·402 per cent.
Fixed carbon... ...	70·10	Coke, 81·7 per cent. Not much swollen, dull and firm.
Ash	11·60	Ash, dark-grey.
	100·00	

Splint Coal, B on sections.

Moisture	1·02	Sulphur, 0·508 per cent.
Volatile hydro-carbons	16·63	Specific gravity, 1·372 per cent.
Fixed carbon... ...	72·95	Coke, 82·35 per cent. Slightly swollen, dull and firm.
Ash	9·40	Ash, light-grey.
	100·00	

Semi-bituminous Coal, C on sections.

Moisture	0·78	Sulphur, 0·535 per cent.
Volatile hydro-carbons	19·52	Specific gravity, 1·428 per cent.
Fixed carbon... ...	65·20	Coke, 79·7 per cent Well swollen, very bright, and fairly firm.
Ash	14·50	Ash, light-grey.
	100·00	

Semi-bituminous Coal, D on sections.

Moisture	0·77	Sulphur, 0·343 per cent.
Volatile hydro-carbons	19·13	Specific gravity, 1·502 per cent.
Fixed carbon... ...	62·35	Coke, 80·10 per cent. Well swollen, lustrous, and firm.
Ash	17·75	Ash, light-grey.
	100·00	

The company hold 1,800 acres of land on mineral lease from the Crown, at a royalty of 6d. per ton on large and 3d. per ton on small coal raised.

The winding-shaft is 451 feet above sea-level, 16 feet in diameter, 1,098 feet to the No. 1 Coal Seam, and 46 feet additional to the No. 2; and is situated 24 chains from the Government Railway, to which a branch line has been constructed.

An air-shaft, 15 feet in diameter, is in course of sinking to the No. 1 Coal, where a large Walker fan, for ventilating purposes, is erected.

A winding-engine, with two coupled 34-inch cylinders and 5 feet 6 inch stroke, three Lancashire boilers, 26 feet 2 inches by 8 feet 2 inches, and three screens, are in course of erection; and the company expect to be raising 800 tons of coal per day shortly, to be ultimately increased to 1,000 tons per day.

This colliery is equipped with the finest plant in Australia, and it is only to be regretted that a more advantageous site for the principal winning was not chosen.

The Illawarra group appears to consist of about nine seams, of which none are at present worked except the No. 1 and No. 2 Seams. The latter, 2 feet 4 inches thick, is worked to a small extent at the Bulli Colliery. In the extreme south of the coal-field at Jervis Bay two thick seams of coal are met with, the upper of which is 39 feet in thickness, but only the lower 10 feet 6 inches of it is supposed to be workable. The so-called No. 3 Seam is about 24 feet in thickness, of which 10 feet is supposed to be workable. These seams (which are known as the Jamberoo seams) are thought to be on the geological horizon of the Greta beds.

Coal is worked on a small scale on the line of the Southern Railway at Mittagong, Berrima, and other points. The section at Berrima is 18 feet 3¼ inches, of which 11 feet 2 inches is coal.

In the western district Lithgow is the principal centre. All the collieries in this district are within a short distance of the Great Western Railway, and they have for many years had a considerable share in supplying coal to the Government railways for locomotives. The western collieries almost doubled their output between 1880 and 1886, the quantity raised by them in 1880 being 146,960 tons, and in 1886 281,229 tons.

The following is the section of the No. 2 Seam opened out and proposed to be worked by the Gladstone Coal Company :—

	Coal. Ft.	Coal. In.	Bands. Ft.	Bands. In.	Ft.	In.
Coal	1	5				
Band			0	3		
Coal	1	5				
Band			0	0½		
Coal	2	8				
Band			0	4		
Coal	1	6				
Total thickness of seam	7	0	0	7½	7	7½

Two adits have been driven into the coal at the face of the cliff, and the coal wrought out to a height of 7 feet.

The Lithgow Seam worked at the Vale of Clwydd Colliery has a thickness of 10 feet 7¾ inches. The following is the section :—

	Coke. Ft.	Coke. In.	Bands. Ft.	Bands. In.	Ft.	In.
Coal	1	3¼				
Indurated clay			0	1		
Coal	1	0				
Indurated clay			0	0¼		
Coal	1	2				
Indurated clay			0	0¼		
Coal	3	0				
Band			0	0¼		
Coal	3	0				
Band			0	0½		
Coal (left)	1	0				
Total thickness	10	5½	0	2¼	10	7¾

Coal worked in some places.

It is very free from faults, lies very regular, and dips about 1 in 20 east.

At the Lithgow Valley Colliery the seam worked is 10 feet 6 inches thick, about 5 feet 6 inches of which is worked through an adit in a mountain on the western boundary. This company have introduced a complete plant from England, and the machinery contains all the latest improvements.

At the Ballimore Coal Company's Colliery the coal seam is 13 feet 7¼ inches thick, of which 6 feet 7 inches is coal. The coal is highly bituminous, and is very similar in character to that worked at the Greta Colliery, Branxton.

A few miles from Ballimore, a 4 feet 6 inches coal, somewhat similar to the Lithgow coal, only coarser grained, has been sunk through, and permission to work the coal applied for. It is believed to be the No. 1, or Uppermost Seam, in the Ballimore Coal-measures, and may exist under the conglomerates, pudding stones, and sandstones which overliethe Ballimore Coal Seam.

There is a large extent of country in which these Coal-measures exist—north, south, east, and west of the Ballimore Mine, the commercial value of which can only be shown by provings by adits, borings, or sinkings.

The outlying coal-fields of Dubbo and the Clarence River are at present very slightly developed, though it is believed there are some fine seams in the latter area. It is, however, more related to the Queensland coal-fields than those of Newcastle, and, as its latitude is nearly within the tropics, it will probably only have a local importance for the present.

Statistics.

Having briefly described the physical characteristics of the coal-field, it will be convenient to give in this place some statistics of the present production of the collieries. The latest returns at present available are those for 1889, and these are really more reliable than those for 1890 would be, even if the latter were published, as the trade has suffered so much during the past year from strikes and trade disturbances.

The output of coal for 1889 shows, as compared with that of 1888, an increase of 452,188 tons, while the increase in 1888 over that of 1887 was only 280,947. The value of the coal raised in 1889 as compared with that of 1888, shows an increase of £177,650, against an increase in 1888 over 1887 of £108,758. The total export of coal in 1889 shows an increase in quantity of 463,830 tons, and in value of £214,799, as compared with 1888. The export of coal to colonial ports shows an increase in quantity of 270,464 tons, and in value of £113,907, as compared with 1888. The export of coal to foreign ports shows an increase in quantity of 193,366 tons, and in value of £100,892 upon that of 1888, which was then the largest quantity ever sent in one year to foreign ports. The average price of coal on the whole output was 8s. 11·20d. per ton; the average price of that sent to colonial ports was 10s. 4·24d. per ton; the average price of that sent to foreign ports was 11s. 1·88d. per ton, being a decrease on the whole output equal to 1·82d. per ton on that sent to colonial ports, equal to 6·01d. per ton on that sent to foreign ports, equal to 1·89d. per ton. Notwithstanding the decrease in price, the improvement in trade may, I think, be regarded as eminently satisfactory.

QUANTITY AND VALUE OF COAL RAISED FROM THE OPENING OF THE COAL SEAMS TO 1857, INCLUSIVE :—

Year.	Quantity.	Average per ton.	Value.	Year.	Quantity.	Average per ton.	Value.
		£ s. d.	£			£ s. d.	£
Prior to 1829	50,000	0 10 0	25,000	1844	23,118	0 10 8·34	12,363
1829	780	0 10 1·23	394	1845	22,324	0 7 10·27	8,769
1830	4,000	0 9 0·00	1,800	1846	38,965	0 7 0·46	13,714
1831	5,000	0 8 0·00	2,000	1847	40,732	0 6 9·01	13,750
1832	7,143	0 7 0·00	2,502	1848	45,447	0 6 3·38	14,275
1833	6,812	0 7 6·73	2,575	1849	48,516	0 6 0·45	14,647
1834	8,490	0 8 10·00	3,750	1850	71,216	0 6 6·77	23,375
1835	12,392	0 8 10·19	5,483	1851	67,610	0 7 6·51	25,546
1836	12,646	0 9 1·05	5,747	1852	67,404	0 10 11·33	36,885
1837	16,083	0 9 8·81	7,828	1853	96,809	0 16 1·51	78,059
1838	17,220	0 9 9·05	8,399	1854	116,642	1 0 5·63	119,380
1839	21,283	0 9 9·73	10,441	1855	137,076	0 12 11·96	89,082
1840	30,256	0 10 10·86	16,498	1856	189,960	0 12 4·06	117,906
1841	34,841	0 12 0·00	20,905	1857	210,434	0 14 0·97	148,158
1842	39,900	0 12 0·00	23,940				
1843	25,862	0 12 6·54	16,222		1,468,961	0 11 10·72	869,391

Coke manufactured in New South Wales during the year 1889 :—

	Tons.	Value. £	s.	d.
Northern District	16,626 ...	26,601	12	0
Southern „	5,945 ...	6,131	0	0
	22,571 ...	32,732	12	0

The number of collieries under inspection in 1889 was 67 coal and 1 shale mines in the northern district ; 16 coal and 2 shale mines in the western district; and 16 coal and 1 shale mines in the southern district ; total 103, as compared with 91 in 1888.

The number of mines under inspection during the year was 104, and the number opened out, or in course of opening during the year, was 16, and 8 were abandoned as compared with 30 opening out, and 1 abandoned in 1888.

The following comparative statement shows an increase in the output of the northern collieries during 1889, as compared with 1888 of 557,305 tons, value £239,202. Whereas the output of the western and southern collieries show a decrease as compared with that of 1888. The former to the extent of 9,881 tons in quantity, and £13,677 in value, and the latter to the extent of 95,234 tons in quantity, and £47,874 in value. The large decrease in value in the western and southern districts is accounted for by the reduced price of coal from those districts.

TABLE SHOWING THE QUANTITIES AND AVERAGE VALUE PER TON OF COAL EXPORTED TO INTERCOLONIAL AND FOREIGN PORTS RESPECTIVELY, THE QUANTITY OF COAL CONSUMED IN THIS COLONY, AND THE AVERAGE PRICE PER TON OF THE TOTAL OUTPUT OF THE COLLIERIES, FROM 1858 TO 1889 INCLUSIVE :—

Year.	Exports to Intercolonial Ports.				Exports to Foreign Ports.				Total Exports.				Home consumption.	Total Output and Value.					
	Quantity.	Average per ton.			Quantity.	Average per ton.			Quantity.	Average per ton.				Quantity.	Average per ton.			Value.	
	Tons.	£	s.	d.	Tons.	£	s.	d.	Tons.	£	s.	d.	Tons.	Tons.	£	s.	d.	£	s. d.
1858	101,488	0	15	1·67	12,039	1	0	1·85	113,527	0	15	8·05	102,878	216,397	0	14	11·84	162,162	0 0
1859	129,586	0	14	6·67	44,349	0	17	5·27	173,935	0	15	3·49	134,278	308,213	0	13	3·14	204,371	0 0
1860	140,183	0	14	10·85	93,694	0	16	11·10	233,877	0	15	8·57	133,985	368,862	0	12	3·36	226,493	0 0
1861	157,278	0	15	2·25	50,502	0	16	5·37	207,780	0	15	5·92	160,965	134,287	0	12	9·52	342,067	0 0
1862	195,427	0	15	0·55	113,355	0	17	4·34	308,782	0	15	10·75	245,422	167,740	0	12	9·73	476,522	0 0
1863	213,909	0	13	8·40	84,129	0	17	6·10	298,038	0	14	9·30	220,181	135,851	0	10	10·66	433,889	0 0
1864	283,539	0	10	3·74	146,199	0	14	10·90	66,289	0	11	4·91	212,488	176,546	0	9	10·10	549,012	0 0
1865	292,664	0	9	11·83	146,129	0	15	0·79	68,029	0	11	2·20	214,158	202,556½	0	9	4·43	585,525	0 0
1866	344,194	0	9	2·98	159,175	0	14	4·53	141,413	0	11	1·37	300,588	233,333	0	8	4·44	774,238	0 0
1867	312,101	0	9	4·35	146,111	0	13	3·47	107,148	0	10	8·40	253,259	296,655	0	8	10·79	324,049	0 0
1868	329,052	0	9	5·76	155,975	0	12	5·29	136,226	0	10	7·96	292,201	406,195	0	8	9·08	954,231	0 0
1869	340,466	0	8	9·07	149,059	0	11	8·31	149,136	0	10	0·16	298,195	324,231	0	7	6·32	919,774	0 0
1870	335,564	0	8	6·02	142,656	0	10	3·57	125,025	0	9	3·07	267,681	290,175	0	7	3·54	868,564	0 0
1871	378,891	0	8	6·91	162,470	0	10	1·22	94,220	0	9	0·95	256,690	333,352	0	7	0·47	898,784	0 0
1872	394,052	0	8	8·11	170,947	0	9	11·46	136,914	0	9	2·42	307,861	343,316	0	7	9·92	1,012,426	0 0
1873	425,937	0	12	9·32	272,110	0	14	7·59	253,979	0	13	7·32	526,089	419,783	0	11	1·94	1,192,862	0 0
1874	467,583	0	13	8·30	320,119	0	15	4·76	312,128	0	14	5·81	632,247	431,587	0	12	1·37	1,304,612	0 0
1875	518,853	0	13	7·77	354,074	0	15	6·64	317,409	0	14	5·84	671,483	402,722	0	12	3·89	1,329,729	0 0
1876	542,952	0	13	8·45	372,045	0	15	6·45	253,166	0	14	4·70	625,211	451,101	0	12	2·06	1,319,918	0 0
1877	563,757	0	13	8·64	386,740	0	14	10·81	262,237	0	14	2·08	648,977	528,544	0	11	10·74	1,444,271	0 0
1878	623,323	0	13	8·77	427,954	0	14	7·69	280,452	0	14	0·93	708,406	569,077	0	11	8·28	1,575,497	0 0
1879	621,087	0	13	6·75	421,198	0	14	6·13	273,509	0	13	11·05	694,707	585,332	0	12	0·12	1,583,381	0 0
1880	550,672	0	11	2·67	309,004	0	11	5·70	116,295	0	11	3·48	425,299	712,824	0	8	6·36	1,466,180	0 0
1881	657,135	0	7	9·34	255,572	0	8	8·29	161,958	0	8	1·30	417,530	739,753	0	6	9·55	1,769,597	0 0
1882	760,226	0	9	9·54	372,324	0	10	11·50	274,699	0	10	3·09	647,033	847,737	0	8	11·97	2,109,282	0 0
1883	855,704	0	10	5·75	448,356	0	11	7·34	381,306	0	10	11·65	829,662	1,009,612	0	9	6·40	2,521,457	0 0
1884	994,087	0	10	8·66	532,938	0	11	5·14	398,107	0	11	0·15	931,045	1,058,346	0	9	5·71	2,749,109	0 0
1885	991,924	0	10	7·13	525,443	0	11	6·52	441,220	0	11	0·09	966,663	1,122,507	0	9	3·72	2,878,863	0 0
1886	1,027,775	0	10	7·22	544,824	0	11	4·31	402,178	0	10	10·93	947,002	1,094,310	0	9	2·53	2,830,175	0 0
1887	1,077,270	0	10	5·89	565,084	0	11	1·08	395,455	0	10	8·75	960,539	1,132,055	0	9	2·57	2,922,497	0 0
1888	1,039,764	0	10	10·25	564,293	0	11	3·77	500,179	0	11	0·78	1,064,472	1,279,572	0	9	1·02	3,203,444	0 0
1889	1,310,228	0	10	4·24	678,200	1,077,474	0	11	1·88	601,071	2,387,702	0	10	8·58	1,279,271	1,267,930	3,655,632	0	8 11·20	1,632,848	15 6
Totals	16,976,671	0	11	1·13	9,417,600	11,289,795½	0	12	4·67	6,993,426	28,266,466½	0	11	7·33	16,411,026	17,068,555½	45,335,012	0	9 8·03	21,917,764	6 4

COMPARATIVE STATEMENT OF OUTPUT OF COAL IN THE NORTHERN, WESTERN, AND SOUTHERN DISTRICTS.

	1884.		1885.		1886.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons. c. q.	£ s. d.	Tons. c. q.	£ s. d.	Tons. c. q.	£ s. d.
Output, Northern District ...	2,055,342 10 3	1,011,933 13 7	2,113,372 13 0	1,032,904 13 4	2,178,116 0 0	1,084,554 17 1
Increase as compared with previous year	155,722 14 3	83,907 0 2	58,030 2 1	20,970 19 9	64,743 7 0	51,650 3 9
Decrease do.	...	...	...	...	...	...
Output, Western District ...	273,823 14 0	74,161 9 7	311,762 16 0	76,836 13 3	281,229 0 0	68,615 15 0
Increase as compared with previous year	41,405 11 0	...	37,939 2 0	2,675 3 8	...	...
Decrease do.	...	3,619 8 11	...	...	30,533 16 0	8,220 18 3
Output, Southern District ...	419,942 9 0	216,981 16 9	453,727 15 3	230,471 7 0	370,830 0 0	149,993 12 0
Increase as compared with previous year	30,523 7 0	20,847 15 9	33,785 6 3	13,489 10 3	...	...
Decrease do.	...	...	...	...	82,897 15 3	80,477 15 0

COMPARATIVE STATEMENT OF OUTPUT OF COAL IN THE NORTHERN, WESTERN, AND SOUTHERN DISTRICTS—*Continued.*

	1887.		1888.		1889.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons. c. q.	£ s. d.	Tons. c. q.	£ s. d.	Tons. c. q.	£ s. d.
Output, Northern District ...	2,243,792 0 0	1,096,720 0 7	2,067,042 4 3	1,022,022 8 10	2,624,347 3 0	1,261,224 16 5
Increase as compared with previous year	65,676 0 0	12,165 3 6	...	...	557,304 18 1	239,202 7 7
Decrease do.	...	...	176,749 15 1	74,697 11 9	...	...
Output, Western District ...	302,137 0 0	79,036 0 2	339,594 9 0	95,136 3 0	329,713 3 0	81,459 1 1
Increase as compared with previous year	20,908 0 0	10,420 5 2	37,457 9 0	16,100 2 10	...	...
Decrease do.	...	...	...	...	9,881 6 0	13,677 1 11
Output, Southern District ...	376,568 0 0	170,684 1 10	796,806 10 0	338,039 12 3	701,572 0 0	290,164 18 0
Increase as compared with previous year	5,738 0 0	20,690 9 10	420,238 10 0	167,355 10 5	...	...
Decrease do.	...	...	...	...	95,234 10 0	47,874 14 3

The average price of coal in the several districts was as follows:—

	1888.		1889.	
	s. d.		s. d.	
Northern	9 10·66	... ...	9 7·34	a decrease of 3·32 per ton.
Western	5 7·23	... ...	4 11·29	„ 7·94 „
Southern	8 5·81	... ...	8 3·26	„ 2·55 „

The returns of the collieries raising coal and shale (boghead mineral) show the following figures for the year 1889 :—

COAL RETURN.

	Northern District.	Southern District.	Western District.	Total.
Tons of round and small coal raised	Tons. cwt. qr. 2,624,347 3 0	Tons. cwt. qr. 701,572 0 0	Tons. cwt. qr. 329,713 3 0	Tons. cwt. qr. 3,655,632 6 0
Value of round and small coal raised	£ s. d. 1,261,224 16 5	£ s. d. 290,164 18 0	£ s. d. 81,459 1 1	£ s. d. 1,632,848 15 6
Persons employed above ground	No. 1,343	No. 467	No. 118	No. 1,928
Persons employed underground	6,216	1,598	535	8,349

PETROLEUM OIL CANNEL COAL OR BOGHEAD MINERAL RETURNS.

Western and Southern Districts.

Tons of boghead mineral or petroleum oil cannel coal	40,561
Value of boghead mineral or petroleum oil cannel coal raised	£77,666 15s.
Persons employed above ground	26
Persons employed underground	112

COKE RETURNED.

Newcastle District	16,626 tons, valued at	£26,601 12s.
Illawarra District, Bulli Company	1,489 „ „	1,675
„ Australian Coke Company, near Kembla ...	4,456 „ „	4,456
	22,571 tons.	£32,732 12s.

COMPARATIVE STATEMENT OF RETURNS FOR 1888-89.

	Men above ground.	Men below ground.	Tons of round and small coal.	Value.
Northern District.			Tons. cwt. qr.	£ s. d.
Australian Agricultural, Newcastle, Wallsend, Newcastle Coal, Lambton, Co-operative, Brown's Duckenfield, New Duckenfield, South Waratah, Ferndale, Wickham and Bullock Island, Hetton, Burwood, Stockton, Maryville, Pride of Ferndale, Goose, Brookstown, Hillside, Linwood, West Burwood, Great Northern, West Wallsend, New Lambton, C Pit, Thornton, Sunderland, Bloomfield, Thornley, Rathluba, South Greta, Greta, New Anvil Creek, Rix's Creek, Ellesmere, New Park, Rosedale, Dulwich, Gladstone, Springfield, Black Jack, Centenary, Clay Cross, Monkwearmouth, Fern Valley, Rosehill, East Lambton, Ebbw Vale, South Wallsend, Summerhill, Northumberland, Teralba, Young Wallsend, Durham, East Greta, Gartlee, Leconfield, and Morriset	1,343	6,216	2,624,347 3 0	1,261,224 16 5
Total in 1889	1,343	6,216	2,624,347 3 0	1,261,224 16 5
„ 1888	1,137	5,736	2,067,042 4 0	1,022,022 8 10
Increase in 1889	206	480	557,304 19 0	239,202 7 7
Southern District.				
Metropolitan, Coal Cliff, North Illawarra, Bulli, South Bulli, Osborne, Wallsend, Illawarra Coal Co., Mount Kembla, Wollongong Coal Co., Mittagong, Australian Kerosene Oil and Mineral Co., Great Southern	467	1,598	701,572 0 0	290,164 18 0
Total in 1889	467	1,598	701,572 0 0	290,164 18 0
„ 1888	432	1,244	796,806 10 0	338,039 12 3
Increase in 1889	35	354	...	...
Decrease in 1889	...	...	95,234 10 0	47,874 14 3
Western District.				
Katoomba, Main Camp, New South Wales, Shale and Oil Co., Oakey Park, Vale, Zig Zag, Vale of Clwydd, Lithgow Valley, Eskbank, Eskbank Old Tunnel, Hermitage, Cooerwull, Lidsdale, Carlo's Gap, and Rawden	118	535	329,713 3 0	81,459 1 1
Total in 1889	118	535	329,713 3 0	81,459 1 1
„ 1888	110	642	339,594 9 0	95,136 3 0
Decrease in 1889	...	107	9,881 6 0	13,677 1 11
Increase in 1889	8	...	...	...

Years.	Exports to Intercolonial Ports.			Exports to Foreign Ports.			Total Exports.			Home consumption.
	Quantity.	Average per ton.	Value.	Quantity.	Average per ton.	Value.	Quantity.	Average per ton.	Value.	
	Tons.	£ s. d.	£	Tons.	£ s. d.	£	Tons.	£ s. d.	£	Tons.
1887	1,077,270	0 10 5·89	565,084	713,172	0 11 1·08	395,455	1,790,442	0 10 8·70	960,539	1,132,055
1888	1,039,764	0 10 10·25	564,293	884,108	0 11 3·77	500,179	1,923,872	0 11 0·79	1,064,472	1,279,570
1889	1,310,228	0 10 4·22	678,200	1,077,474	0 11 1·88	601,071	2,387,702	0 10 8·58	1,279,271	1,267,930
	3,427,262	0 10 6·57	1,807,577	2,674,754	0 11 2·29	1,496,705	6,102,016	0 10 9·90	3,304,282	3,679,555

Years.	Total Output and Value.			Coal raised per each person employed in and about the Mines.			Value of Coal raised per each person employed in and about the Mines.			Tons of Coal raised per each life lost.		
	Quantity.	Average per ton.	Value.	Quantity.	Average tons per each person employed.	Persons employed.	Value.	Average value per each person employed.	Persons employed.	Quantity.	Average tons per each life lost.	Lives Lost.
	Tons.	£ s. d.	£	Tons.	Tons.	No.	£	£ s. d.	No.	Tons.	Tons.	No.
1887	2,922,497	0 9 2·57	1,346,440	2,922,497	365	7,998	1,346,440	168 6 1	7,998	2,922,497	31,090	94
1888	3,203,442	0 9 1·06	1,455,197	3,203,442	344	9,301	1,455,197	156 9 1	9,301	3,203,442	213,562	15
1889	3,655,632	0 8 11·10	1,632,848	3,655,632	355	10,277	1,632,848	158 17 8	10,277	3,655,632	89,161	41
	9,781,571	0 9 0·80	4,434,485	9,781,571	354	27,576	4,434,485	160 16 2	27,576	9,781,571	65,210	150

From these returns we find that in the northern district, in the year under notice, there has been an increase of 557,305 tons in the quantity of coal raised, and £239,202 7s. 7d. in the value of it, whilst in the previous year (1888), when there was a strike of thirteen weeks, there was a decrease of 176,749 tons, and in the value of the coal raised £12,165.

In the southern district there has been a decrease of 95,234 tons, and in the value of £47,874, whilst in the previous year (1888) there was an increase of 420,228 tons, and in the value of £167,355. For the large increase in the output of coal in 1888, the southern collieries were indebted to the northern district thirteen weeks' strike.

In the western district there has been a decrease of 9,881 tons, and in value of £13,677, whilst in the previous year (1888) there was an increase of 37,457 tons, and in value of £16,100. Last year's (1888) larger increase occurred through the northern district strike.

The foregoing table shows comparisons between the year under notice and two preceding years, as regards the exports of coal to foreign and intercolonial ports; the quantity used for home consumption; total output and value; tons of round and small coal raised for each person employed in and about the collieries; value of round and small coal raised for each person so employed; and the quantity of coal raised for each life lost.

NORTHERN DISTRICT.

Number of persons employed in and about the mines ...	7,559
Number of persons employed underground	6,216
Quantity of coal raised in tons	2,624,347
Number of non-fatal accidents	47
Number of lives lost by accidents	32
Persons employed per each non-fatal accident	160
Persons employed per each life lost	236
Tons of round and small coal raised per each non-fatal accident	55,837
Tons of round and small coal raised per each life lost ...	82,010
Tons of coal raised per each person employed in and about the mines	347
Tons of coal raised per each person employed underground	442
Value of coal raised	£1,261,225 0 0
Value of coal raised per each person employed in and about the mines	£166 17 0
Value of coal raised per each person employed underground	£202 17 11

SOUTHERN DISTRICT.

Number of persons employed in and about the mines ...	2,065
Number of persons employed underground	1,598
Quantity of coal raised in tons	701,572

Number of non-fatal accidents	8
Number of lives lost by accidents	7
Persons employed per each non-fatal accident	258
Persons employed per each life lost	295
Tons of round and small coal raised per each non-fatal accident	87,696
Tons of round and small coal raised per each life lost ...	100,224
Tons of coal raised per each person employed in and about the mines	339
Tons of coal raised per each person employed underground	439
Value of coal raised	£290,165 0 0
Value of coal raised per each person employed in and about the mines	£140 10 3
Value of coal raised per each person employed underground	£181 11 7

Western District.

Number of persons employed in and about the mines ...	653
Number of persons employed underground	535
Quantity of coal raised in tons	329,713
Number of non-fatal accidents	2
Number of lives lost by accidents	2
Persons employed per each non-fatal accident	326
Persons employed per each life lost	326
Tons of round and small coal raised per each non-fatal accident	164,856
Tons of round and small coal raised per each life lost ...	164,856
Tons of coal raised per each person employed in and about the mines	504
Tons of coal raised per each person employed underground	616
Value of coal raised	£81,459 0 0
Value of coal raised per each person employed in and about the mines	£124 14 11
Value of coal raised per each person employed underground	£152 5 2

The following table shows comparisons between the year under notice and the preceding year, as regards the proportion the accidents and deaths bear to the persons employed, the quantity and value of the coal for each person employed in and about the mines and underground, in the Northern, Southern, and Western Districts :—

	Northern District.		Southern District.		Western District.	
	1888.	1889.	1888.	1889.	1888.	1889.
Number of persons employed in and about the mines	6,873	7,559	1,676	2,065	752	653
Number of persons employed underground	5,736	6,216	1,244	1,598	642	535
Quantity of coal raised in tons ...	2,067,042	2,624,347	796,806	701,572	339,594	329,713
Number of non-fatal accidents ...	32	47	7	8	4	2
Number of lives lost by accident	9	32	5	7	1	2
Persons employed per each non-fatal accident	214	160	239	258	188	326
Persons employed per each life lost	763	236	335	295	752	326
Tons of round and small coal raised per each non-fatal accident	64,595	55,837	113,829	87,696	84,898	164,856
Tons of round and small coal raised per each life lost ...	229,671	82,010	159,361	100,224	339,594	164,856
Tons of coal raised per each person employed in and about the mines	300	347	475	339	451	504
Tons of coal raised per each person employed underground	360	422	640	439	528	616
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Value of coal raised	1,022,022 8 10	1,261,225 0 0	338,039 12 3	290,165 0 0	95,136 0 0	81,459 0 0
Value of coal raised per each person employed in and about the mines	148 14 0	166 17 0	201 13 10	140 10 3	126 10 2	124 14 11
Value of coal raised per each person employed underground	178 3 6	202 17 11	271 14 0	181 11 7	148 3 8	152 5 2

NEWCASTLE.—New South Wales export of coal during the years 1888 and 1889.

COUNTRIES.	1888.	1889.	Increase.	Decrease.
	Tons.	Tons.	Tons.	Tons.
Victoria	666,947	811,818	144,871	—
New Zealand	138,007	156,172	18,165	—
South Australia	74,250	181,411	107,161	—
Queensland	—	5,319	5,319	—
Tasmania	33,514	61,585	28,071	—
Western Australia ...	11,814	14,780	2,966	—
Hong Kong	36,953	79,826	42,873	—
Java	32,288	70,494	38,206	—
New Caledonia	9,108	10,838	1,730	—
Singapore	17,879	39,057	21,178	—
Mauritius...	7,081	15,422	8,341	—
Fiji	7,259	10,966	3,707	—
United States	314,593	296,357	—	18,236
India	34,643	62,216	27,573	—
Philippine Islands ...	33,084	45,026	11,942	—
Peru	9,186	23,044	13,858	—
Sandwich Islands ...	21,418	27,081	5,663	—
Mexico	2,193	9,601	7,408	—
Chili	100,631	145,237	44,606	—
Solomon Islands... ...	—	1,428	1,428	—
South Sea Islands ...	3,632	3,642	10	—
Africa	400	487	87	—
Ceylon	1,685	2,438	753	—
Macassar	—	3,740	3,740	—
Haiphong...	—	933	933	—
Yokohama	—	1,003	1,003	—
Sumatra	—	5,449	5,449	—
Guam	—	3,328	3,328	—
Penang	1,130	1,654	524	—
Bangkok	—	725	725	—
United Kingdom ...	—	480	480	—
New Guinea	485	—	—	485
Indo-China	1,367	—	—	1,367
Queensland	5,074	—	—	5,074
South America	14,822	—	—	14,822
New Hebrides	894	—	—	894
	1,580,337	2,091,557	552,098	40,878

Total increase for 1889 is 511,220 tons.

Export of Coke from Newcastle for the year 1889.

South Australia	11,460	8,313	—	3,147
Victoria	2,606	13	—	2,593
New Caledonia	—	35	35	—
Haiphong	—	33	33	—
Tasmania	—	13	13	—
New Zealand	—	31	31	—
United States	398	—	—	398
United Kingdom... ...	150	—	—	150
India	4	—	—	4
	14,618	8,438	112	6,292

Total decrease for 1889 is 6,180 tons.

DECENNIAL RETURN.—Port of Newcastle.—Foreign and Intercolonial Ports.

Year.	Vessels cleared outwards for Foreign and Intercolonial Ports.		Total value of Imports from Foreign and Intercolonial Ports.	Quantity and value of Coal exported to Foreign and Intercolonial Ports.		Total value of Exports (inclusive of Coal) to Foreign and Intercolonial Ports.	Total amount of Revenue collected.
	No. of Vessels.	Tonnage.		Tons.	Value.		
			£ s. d.		£ s. d.	£ s. d.	£ s. d.
1880	1,023	516,480	527,905 0 0	673,393	372,378 0 0	477,486 0 0	57,883 4 6
1881	1,121	654,543	482,845 0 0	899,369	343,931 0 0	407,212 0 0	77,543 10 7
1882	1,143	737,772	632,073 0 0	1,080,446	527,575 0 0	618,586 0 0	76,799 12 7
1883	1,305	926,956	658,601 0 0	1,35,9505	722,428 0 0	1,440,752 0 0	87,844 12 0
1884	1,433	1,066,462	788,653 0 0	1,505,395	835,070 0 0	1,699,047 0 0	108,720 0 0
1885	1,388	1,076,346	930,200 0 0	1,552,136	832,495 0 0	1,927,626 0 0	108,834 18 6
1886	1,335	1,097,382	843,474 0 0	1,544,694	828,189 0 0	1,398,728 0 0	119,131 15 0
1887	1,334	1,154,439	781,796 0 0	1,658,386	886,921 0 0	1,788,664 0 0	117,543 7 10
1888	949	815,516	758,586 0 0	1,580,337	852,083 0 0	2,067,460 0 0	126,036 7 9
1889	1,277	1,126,892	924,150 0 0	2,091,557	1,102,722 0 0	1,894,321 0 0	132,018 0 1

The foregoing statistical return, furnished by Mr. W. R. Logan, the Collector of Customs at Newcastle, shows that the greatest increase in the export of coal from that port has been:—To Victoria, 144,871 tons; South Australia, 107,161; Chili, 44,606; Hong Kong, 42,873; Java, 38,206; Tasmania, 28,071; Philippine Isles, 27,573; Singapore, 21,178; and New Zealand, 18,165; and the greatest decrease to the United States, 18,236; and South America, 14,822.

SYSTEMS OF WORKING.

The system on which coal is for the most part worked in New South Wales approximates to that practised in some of the collieries in the South Wales district, and generally known as "pillar and stall." This system has doubtless arisen in the neighbourhood of Newcastle from the special conditions obtaining there, and has been gradually extended to other localities. At Newcastle the great thickness of the Borehole Seam, and the necessity for supporting the strata where there was water overhead, very naturally suggested the idea of getting the coal out in bords or stalls, and keeping the strata up by leaving ribs or pillars of coal between them. It is needless to remark on the extraordinary wastefulness of this system, and it is much to be feared that the ribs of coal left for support are permanently lost, as any attempt to get them would probably bring on a "creep." The system is generally condemned by the best Australian mining engineers, and other systems are now being introduced; but any change is attended with very great difficulty, owing to the determined opposition of the miners and their unions. The writer has never been able to ascertain on what grounds change is so strenuously resisted, but it has probably something to do with a fear of disturbing the mystic hewing price of 4s. 2d. per ton—a figure sacred in the eyes of the Australian miner, and not to be tampered with by adopting any easier method of working the coal. As might be expected in a democratic community, Parliament is inclined to legislate in the direction desired by the workers; and last year a Bill passed the Lower House of the New South Wales

Parliament which would have stereotyped many very objectionable practices, notwithstanding the tremendous sacrifice of national wealth in the shape of coal left permanently in the mines. The Upper House, however, referred the matter to a Select Committee, and the consensus of evidence from the best mining experts was so strong that it is to be hoped the Bill will not be re-drafted on its present lines.

The section of the Borehole Seam at the Australian Agricultural Company's Colliery, can only be completely extracted either by successive longwall operations, or by the following method, which is proposed to be pursued by the Australian Agricultural Company:—

The pit will be laid out in panels, and equal widths of coal (viz., 8 yards) will be taken out in the bords and left in the pillars. The centre of the seam, 8 feet 4 inches thick, will be first worked in the bords until the panel is completed; then the bottom coal will be got up in a second operation; and, last of all, the pillars are to be got by a species of longwall, being brought back obliquely from a corner of the panel, the 3 feet 8 inches of roof-coal left standing in the bords being got out, as far as possible, with the pillar coal. This system would be a new departure, but the able manager, Mr. Turnbull, is sanguine that he will succeed in getting nine-tenths of the coal.

At the Durham New Winning of the Scottish-Australian Company, an attempt will be made by Mr. Croudace to work the coal on the North of England pillar system, or by longwall. At the Greta Colliery, it has been decided to lay out large pillars, 70 yards by 40 yards, and to work these out by cross juds. It must, however, be evident that the best system of working coal must vary with special circumstances, and that any attempt to legally stereotype any particular system, however excellent under certain conditions, would be an egregious blunder. It may be necessary to lay down rules for working coal under the sea or under estuaries, especially with such shallow and thick seams as those of the Newcastle district, but even in such cases any method adopted should be so designed as to make the removal of the pillars possible when the "whole" workings have been pushed as far seaward as possible, provided that experience shows that this can be done with safety. In the recent Mines Bill, already referred to, the rule was to be to take out 6-yard bords and leave 8-yard pillars, which, allowing for waste and strait work, would involve the loss of two-thirds of the coal. The quantity left in pillars is, in this case, either too much or too little. Too much if there is no intention of ever working the pillars, and too little to secure an economical working of the pillars if they are to be finally brought back. As far as the writer was able to judge of the character of the overlying strata, there would appear to be less danger working the coal by longwall in two layers than in any other way which would admit of getting most of the coal, the solid coal being forewon by the formation of large pillars so as to explore the field in advance; the one risk would be in the neighbourhood of certain trap-dykes, where the goafing of the coal might cause open cracks, which would, of course, be highly dangerous. Probably the system proposed by Mr. Turnbull for

working out the pillars at the Australian Agricultural Company's Sea Pit, or some modification of it, will be adopted, unless the removal of the pillars by any system is forbidden by law.

In most respects the Newcastle collieries are worked on lines similar to the home collieries of Northumberland and Durham, the arrangements and technical terms being the same. Most of the miners hail from the North Country, and the Tyneside dialect is every bit as pronounced in the Australian as in the English Newcastle.

Till quite recently the plant of Australian collieries was hardly up to the modern English standard, but this may be explained by the very favourable conditions under which the mining has been hitherto done. With shallow pits and thick seams much machinery was not needed, but at the newer collieries modern plants are being put down. At one new and extensive colliery very large and elaborate fuel economizers have been put in, though the small coal in that particular case was almost unsaleable, and a good deal of it is tipped over the heap—a case where modern improvements have been carried a little too far, but indicating that Australia intends to have everything up to date before long. If coal should be proved under Sydney it will be at a depth of 1,000 yards, and plant of a very powerful class will be required.

The Australian mines are, as a rule, very free from gas, and safety-lamps are not very generally used, but this is only a question of time. As the mines get deeper they will probably become more gaseous, and safety-lamps will follow as a matter of course. At the Metropolitan Colliery, Helensburgh (Illawarra district), a dangerous gas, approximating to carbonic oxide, has been met with. Its specific gravity is slightly greater than that of air, so that it lies along the ground, a circumstance which makes it all the more dangerous.

Explosions of fire-damp have not been numerous, the worst case being the accident at the Bulli Colliery in 1887, when 81 lives were lost. In the case of this explosion the effects seem to have been aggravated by coal-dust.

The absurdly high cost of labour in Australia seems to point to the adoption of labour-saving machinery, but its introduction will probably be looked upon with some jealousy by the miners' unions. These organizations are more powerful in Australia than with us. They assume a right of interference with the management of the mine which seriously hampers the managers, and frequently overrides them. In the Northern district particularly the Union may almost be said to be supreme. At nearly all collieries the branch of the Union has an executive committee before whom any change in the system of working, even of the most trivial kind, is brought by the miners. The first impulse is to resist any change whatever, no matter what the circumstances, and many managers think it good policy to let the men's committee know beforehand any alterations they may contemplate, and their reasons, so as to disarm opposition. Still the system is most unsatisfactory to those who have the responsible charge of mines. Mr. Croudace, who probably occupies the highest position as a mining engineer in Australia, told the writer

that, in a conversation with Mr. Curley, M.P., President of the Northern Union, he mentioned the system on which he intended to work a new colliery he was opening out. He was promptly told the Union would not allow him to do so, to which Mr. Croudace replied that it would be a trial of strength, for he intended to persist. This shows how very unprogressive, if not reactionary, the views of trades unions sometimes may be. Of course, at out-of-the-way collieries, where men cannot easily come and go, a firm manager can rid himself of a good deal of this tyranny; but in the Newcastle district it is very irksome. A manager desirous of working economically is confronted with a most resolute opposition. For example: At a colliery in the Northern district the system of haulage was changed from "tail" to "endless" rope, and a continuously-running engine substituted for the tail-rope engine. The manager appointed a youth of sixteen to oil and watch the new engine at 4s. a day, but he at once received a letter from the Enginemen's Union insisting on the employment of a man at 9s. The manager had to submit, but to emphasize the absurdity of the demand he retained the youth at the job, though he had to pay him 9s. a day instead of 4s. Altogether the labour question is one of the most important factors in Australian mining, and is, I fear, destined to curtail its expansion to the extent which it might otherwise be expected to attain.

Markets.

The growth of the New South Wales coal trade has been very remarkable, as will have been seen from the figures already given; but it would be rash to infer that it will continue in the future to progress with the same rapidity as hitherto. It is true that there are boundless areas of easily accessible coal, and these are being opened up so rapidly that so far as capacity of production is concerned there would be no difficulty in far exceeding the progressive increase of the past. But signs are not wanting that the limits of the export trade are being approached, and, as the Australian consumption proper is limited, the increased output can only be placed on foreign markets.

The principal outside markets for Australian coal have hitherto been San Francisco and other Pacific ports of the United States, Chili, Peru, and the Eastern Archipelago. All these markets are now being invaded by other coals, which will probably to some extent displace Australian coal. The United States markets will be more and more supplied from the vast coal-fields of the Rocky Mountains or Vancouver's Island; the Eastern Archipelago possesses important coal deposits in Borneo, Java, etc., which are now just beginning to be developed; and the Japanese are putting large quantities of cheap coal on this market. When the mines of China and Tonquin are opened up, Australia will probably be in some danger of having to defend her home trade by protective duties. The present export trade to America consists largely of return cargoes, and when wheat or other freight is offering there is even now often a great dearth of tonnage for the collieries. The war now raging in Chili must paralyse that trade for a time, and the excellent coal of New

Zealand is destined in the future to be a serious competitor for the Victorian, Tasmanian, and South Australian trade. Altogether the outlook for the future is not so bright as could be wished, and many of the collieries placed at a distance from a port will find considerable difficulty in disposing of their output with profit. The Southern or Illawarra district enjoys some advantages over the Northern, the chief of which are that the hewing price in that district is only 2s. 4d. per ton as against 4s. 2d. at Newcastle, and the Southern coal is preferred for steamers, which will ensure a considerable share of the most valuable of the home trade. The Newcastle Borehole coal commands, as a rule, from 2s. 6d. to 3s. per ton higher price than the Southern coal at Sydney, but this difference will probably be reduced ere long. The current prices for coal are 11s. f.o.b. Newcastle, as against 8s. 6d. f.o.b. Southern jetties, or Wollongong.

The price of coal in the Newcastle district is regulated by a "Vend" agreement, or ring, to which most of the older collieries belong. The rules of the Vend are given in Appendix C.* Each associated colliery must deposit a sum of £3,000 as security for good faith, a breach of which involves its forfeiture. The Vend Association fixes the price of coal from time to time, and no variation is permitted. A certain output is fixed for each colliery, and if that output be exceeded a heavy fine has to be paid to the Vend Association in respect of every ton sold over the output permitted. On the other hand, the quantity sold in excess of the fixed allowance gives a colliery a right to have its allowance increased by 50 per cent. of the excess in the following year. In the same way, a colliery which does not work up to its allowance is paid for every ton short, but in the following year that colliery forfeits its right to 50 per cent. of the deficiency. The weakness of this arrangement is that it is opposed to the interests of new and increasing collieries, and is also very favourable to those whose coal enjoys a special reputation. Thus ships frequently arrive at Newcastle with instructions to load either Wallsend or Greta coal, so that those collieries would work while others must stand idle. They have, of course, to pay towards the support of the less favoured collieries, but they are continually increasing their allowed output year by year. There are, moreover, more collieries outside the Vend than in it, and in times when competition is severe, these outside collieries will cut prices. That the Vend will probably not remain a permanent institution has lately been indicated by the secession of the important Duckenfield Collieries, whose Borehole coal is now being sold at considerably less than Vend prices. Indeed, there can be no doubt that 11s. f.o.b. is too high a price for such markets as San Francisco at the present time, and as local American coals are more and more developed, this will militate against the importation of Australian coal.

The shipping arrangements at "the Dyke" in Newcastle Harbour are admirable. Eight powerful hydraulic cranes lift the bodies of the railway trucks over the holds of the ships, and loading is most expeditiously accomplished. At Catherine Hill Bay, Bellambi, and Port Kembla there are fine colliery jetties for loading ocean-going

* See Appendix C, page 311.

steamers, and some ambitious dock schemes have been proposed at various points on the coast. A revolution in the trade must, however, be produced if the borings at North Sydney prove coal at a workable depth. As already stated, the Sydney and Port Hacking Syndicate's bore has reached a depth of 2,300 feet, and gas has been given off. The Coal-measures ought to be touched immediately, and it is to be hoped a workable seam intersected within 3,000 feet. This borehole is situated on Cremorne Point, opposite Sydney, close to deep water, and if the Syndicate find coal they will practically monopolize the bunker-coal trade of Sydney. Freights from Newcastle and Illawarra to Sydney run from 2s. 6d. to 3s. per ton, which ought to more than compensate for the extra cost of working at so great a depth. It is possible, however, that the deep coal may be more bituminous than the Illawarra steam coal, in which case it would not be so suitable for bunker coal.

The Australian home market, in addition to the steamer lines, includes the coal for railways, gasworks, and factories. As the colonies develop the consumption of the railways will materially increase, the quantity of coal required for gas making will probably not increase to the same extent, as the electric light is likely to some extent to supersede gas for town lighting. The manufactures of Australia are as yet in their infancy, but doubtless in course of time there will be a considerable consumption under this head. The warmth of the climate does not make house coal so important a factor in the trade as with us. There is an increasing demand for coke for silver smelting, but the New Zealand coal, which is remarkably pure, is better adapted for coking than most of the Australian coals, and will probably be the chief source of coke supply for the Broken Hill and Tasmanian mines. An important step will have been taken when the first iron-smelting works are established. Beds of excellent ironstone exist in New South Wales, particularly in the neighbourhood of Wallerawang, on the western slope of the Blue Mountains, and in the Illawarra district. So long as New South Wales adhered to a Free Trade policy, iron could not be profitably manufactured locally to compete with the imported article; but one result of the federation of the Australian colonies will be to put an end to Free Trade in New South Wales, even if the federation tariff is lower than those now enforced in the Protective colonies. Amongst the results which will probably result from federation it may be predicted that the manufacturing industries, which are at present chiefly located in Victoria, will be transferred to towns in the neighbourhood of the coal-fields of New South Wales, while the pastoral trade of the Riverina district of the latter colony will tend to gravitate towards Melbourne and Adelaide, or Port Pirie. Whether the mining industry of New South Wales will find Protection operate to its advantage may be doubted, but under existing circumstances the change was clearly inevitable.

Tenure of Mines.

The tenure under which mining leases are held in New South Wales are sometimes founded on the old mining law, more generally upon that now in force, and in some cases under leases from private owners of the freehold. Until the year 1875 the

sale of land to private individuals comprised the minerals; hence land purchased from the Government prior to the year 1875 carried with it the underlying minerals. Since that year, however, all minerals have been reserved by the State, and are leased in accordance with the Act of 1874. Mining leases may be granted by the Government for areas not exceeding 640 acres, or below 40 acres for coal, nor less than 20 nor more than 80 acres for other minerals, for a period of not more than twenty years, with the right of renewal for another twenty years, subject to a rent of 5s. per acre, to be paid annually in advance, and to the condition of employing upon the land licensed a certain number of miners, specified in each lease, according to circumstances. Notice in writing to the Government during the nineteenth year is necessary before renewal, and the fee for such renewal is to be determined by appraisement, but it is not to be less than £2 10s. per acre.

The royalty is usually 6d. per ton on the output of large coal. Under the old mining law coal leases were granted on almost nominal terms, and many of the older collieries about Newcastle enjoy great advantages from the possession of early leases. Of course, where the minerals are the property of private owners the terms will vary according to circumstances. Ninepence per ton, however, is a usual royalty rent in such cases.

With regard to wayleaves it is not usual for the Government to exact these, but private owners often do so, though not to an exorbitant amount. An extract from the Mining Act at present in force is given in Appendix E.*

The large quantity of easily available coal under Government lands, now accessible for the first time by the extension of the railways, offers great inducements to speculators to take up coal-fields, and after ascertaining the existence of the seams they transfer their rights to limited companies to develop and work them. This is going on to a great extent at the present moment, and will probably continue to do so for some time to come. As many of these coal-fields are offered on the English market it is well to bear in mind that it is not the actual quality and thickness of the seams of coal which may exist in any property, nor the terms on which those minerals are held, so much as the relative cost at which the coal can be put on board ship as compared with existing collieries. As has already been stated the Australian coal trade is not capable of indefinite extension, and, therefore, every new colliery tends to make the position of the existing collieries worse, through the additional competition for the same amount of trade; and if the development, which appears probable, should become an accomplished fact, the quantity of coal put upon the market will be largely in excess of the demand. The old collieries situate in the neighbourhood of Newcastle, and holding leases under the old Mining Act, being close to their shipping port, and having other advantages from their proximity to the town, will always be favourably circumstanced for competing with the newer collieries at a greater distance from the port. It is, therefore, very necessary in estimating the prospects of new undertakings to take fully into consideration the circumstances which have been indicated.

* See page 317.

The writer desires to express his obligations for much information, verbal and otherwise, to Dr. James R. M. Robertson, Professor W. E. Benton, Messrs. W. A. Harper, T. Parton, H. A. Pringle, and other Australian mining engineers. It would be presumptuous for the writer to suppose that in a short visit to an entirely new country he could grasp more than a very general idea of a great and complex industry, and the structure of a country which is still imperfectly surveyed, and with regard to which many problems still perplex the able geologists and mining engineers on the spot. Still, if the paper is taken for what it professes to be, viz., "Notes and Impressions" gathered during a short visit, it is hoped it may, in the absence of any previous paper on the subject, be of some interest to the Institution, pending further communications from others possessing fuller knowledge than the writer can lay claim to.

APPENDIX A.

Extracts from "The Physical Structure and Geology of Australia," by the late Rev. Julian E. Tenison-Woods, F.G.S., F.L.S., Vice-Pres. Linn. Soc., N.S. Wales, written originally for the *Australian Handbook*.

"The physical geography of Australia gives a key to its geology. It is an immense plateau, with a narrow tract of land sometimes intervening between the edge of this elevated area and the sea. The east side is the highest, averaging about 2,000 feet above the ocean. The west side is not more than 1,000 feet above the same. The north is a little higher. The south side is either level with the ocean, or abuts in cliffs upon the sea, ranging from 300 to 600 feet in height.

"The elevation of the west side of Australia being only half that of the east, or even less, and the distance of the central depression being twice as great, we have no drainage towards the interior at all. Whatever water falls from the clouds collects in marshes, which are generally salt. The soil on that side consists generally of disintegrated granite rocks, and is sterile and dry, forming little better than a sandy desert. All the table-land is more or less interrupted with ranges of mountains which do not run for any distance, and are not sufficiently high to give rise to river systems.

"The base of all this table-land of Australia is granitic. Isolated mountains of granite crop out all through the southern and western deserts. It forms the axis of the Australian Alps, and a great portion of the table-land on the west and east coasts consists of the same rock. There are also considerable tracts in which the granite is replaced by upturned Palæozoic strata, mostly slates and schists, with an almost vertical dip. It cannot be said that the granite is the cause of this uplifting, for it has been mostly derived from the same slates, and bears marks in some cases of stratification, inclined at various angles. Lying unconformably

upon the Palæozoic rocks and granite, are certain basins of coal-bearing rocks, belonging to both the Mesozoic and Palæozoic periods. These are found mostly on the eastern and southern end of the table-land, but there is good reason for believing that they are only thinly covered elsewhere, and that a most extensive coal-bearing area may be looked for in Eastern Australia. Over the Coal-measures all round the Continent there is a sandstone with oblique laminations. This formation is also seen in the interior, and I regard it as an eolian or fluviatile deposit. The great central depression or basin of Australia is like the Sahara desert of Cretaceous age. Its limits are unknown, but abundant fossils in blue marl are found on the very summit of the watershed on the east side of Australia north of latitude 28° S., nearly to Cape York, and all round the Gulf of Carpentaria. The western limits of this great Cretaceous basin are unknown. Fossils belonging to it have been collected considerably west of the overland telegraph line. On the south side of Australia, from the commencement of the Great Australian Bight, the land is, with little interruption, a series of Tertiary rocks, representing all the European deposits from the Eocene upwards. It is not known how far they may extend inland. They extend some 300 or 400 miles at the least, but they are not seen at any height above about 600 feet. On the Australian Bight the Miocene beds of limestone, full of fossils, abound on the sea in cliffs of from 300 to 600 feet in height. On other parts of the coast raised beaches with recent shells are common, notably around the colony of Victoria. In the interior all these deposits are overlaid by either volcanic Tertiary lavas, or by sands, clays, and marls, which have been derived from the sub-aerial weathering of the granite and other rocks. The highest portions of all the heads of the table-land, and consequently the sources of all the rivers, are in recent volcanic emanations. This is true for the whole extent of Australia. These volcanic emanations are Tertiary, and they are all near the edge of the table-land. They sweep round the eastern side from north to south, curving round the south side. As far as the Australian Alps they maintain a very uniform age, which appears to be Miocene or later. West of Melbourne they change their character, and become much more modern. Distinct ash cones of craters are preserved, and ash beds, with the remains of existing fauna and flora. The extreme western limit of this volcanic activity is about 100 miles S.S.E. of the mouth of the river Murray, and here it would seem that the volcanic forces in Australia died out. The raised beaches are found near these craters, and have been, doubtless, elevated in connexion with volcanic outbreaks. In this brief sketch no details have been given. They will now be considered a little more closely.

"Two formations of granite have been recognized in Australia, and there may be more. That which forms the central axis of the table-land has a peculiarity which differs from the outer parts in this, that it is rich in mineral veins. It is in such formations that the valuable deposits of tin are found. They also contain veins of silver, lead, and copper. Gold has also been found in granite, but this metal is more common in a formation to be mentioned presently. The most of the

Australian tin deposits are stream tin, that is to say, tin worked out of granite by streams and found in their beds. But veins of tin have also been found in Herberton (Queensland) and in North Australia as rich as any in the world.

"Earlier Palæozoic rocks—in connexion with the granites, slates, and schists of the Cambrian, and probably Laurentian periods—are found. In these are veins containing gold and other metals. As a rule the veins consist more of felspar than any other mineral, and their direction is more often meridional than otherwise. It appears that the auriferous veins in the Cambrian formation of the colony of Victoria run much more nearly north and south than those of the Silurian.

"The gold veins in Cambrian rocks of the same colony are probably eight times more numerous than the Silurian. As a rule the greater number of veins run parallel with the strata in which they are enclosed, and the greatest number of the richest veins strike west of north. In California and Brazil veins run parallel to the mountain chains. In Australia they do so on the eastern side of the Continent, but where the edge of the table-land bends round to the north-west the veins still keep their north and south direction. They are, therefore, independent of the present configuration of the land. East and west veins are usually poorer than the meridional ones, which is not the experience of other countries. It would appear also that, as a rule, gold is not embedded in the quartz, but occurs in a comparatively loose state in the midst of cavities and laminations. Very rich copper veins have been found in rocks of probably Cambrian age in South and North Australia. The ore is a sulphide. As a rule deposits of carbonates of copper in Australia have not proved permanent. Manganese, antimony, bismuth, and graphite are also found in the Cambrian rocks, but are not worked. Characteristic Cambrian graptolites are found in connexion with gold-bearing veins. The species are identical with those found in Sweden, Bohemia, Wales, Ireland, Scotland, and the United States of America. Rocks which, by their included fossils, are seen to be the equivalents of the Silurian of Europe and America, are found in Victoria (Kilmore), New South Wales (Yass, etc.), Queensland (Rockhampton), and Tasmania. Fossils identical with species of the Wenlock and Ludlow beds, and such forms of Silurian life, as *Phacops* (*Portlockia*) *fecundus* Barrande, are equally abundant in the Yering beds, near Melbourne. Devonian rocks, with characteristic fossils, often identical with those of Europe, are found very extensively developed in Victoria (North Gippsland), in New South Wales (Mount Lambie, Sofale, Lachlan River), in Queensland (Gympie, Burdekin, Mount Wyatt). In connexion with the Upper Devonian rocks we have metalliferous veins of gold, silver, and copper. The mines in Gympie are of great richness. Devonian copper veins have not hitherto proved very productive.

"European Carboniferous plants are found in a few places in New South Wales; not, however, in connexion with coal, as at Stroud, Arrowa, and in Queensland, in the Drummond Range. Marine Carboniferous fossils are found in the basin of the Hunter River, generally throughout Tasmania, and in Queensland (Bowen River).

It is a remarkable peculiarity of these marine beds that they are interstratified with plants of a character which is considered Mesozoic in Europe and India. Their exact geological position is very uncertain.

"Directly covering these remains in many parts of New South Wales and Queensland is a sandstone in thick layers with much cross bedding and oblique lamination, and containing Coniferous wood with equisetaceous stems, leaves of cycads, or palms and ferns (*Thinnfeldia, etc.*). The fossils are often the same as those of the Ipswich coal bed. The contained grains of sand are often rounded, and the whole deposit is, in my opinion, eolian, fluviatile, or composed of volcanic ash deposits, mingled with marsh or lacustrine remains. Near Sydney such strata reach, in the Blue Mountains, a thickness of over 1,000 feet. The same kind of formation is scattered throughout the Continent in isolated masses of various extent. They are generally precipitous, and consist, in my opinion, of hardened cores of sandy accumulations.

"In New South Wales such beds lie upon the coal beds, but not always conformably. In Queensland they lie upon the Cretaceous and are probably Tertiary. It would be very difficult, indeed, to draw any line of distinction between the Queensland desert sandstones and those of New South Wales or the Hawkesbury sandstones, as far as lithological character is concerned, and the included plant remains are common to both. But in portions of the Hawkesbury sandstone, fossil ganoid fishes of the genera *Cleithrolepis* and *Myriolepis* are found, which have strong resemblance (as far as imperfect specimens would admit of comparison) to Devonian forms. In the fresh-water sandstones the Permian *Palæoniscus* is found. Nevertheless, it would be injudicious to consider the Hawkesbury sandstone as of Palæozoic or Lower Mesozoic age. The anomaly of the fish remains we must explain by recalling that we have living amongst us two species of the Liassic and Triassic genus *Ceratodus* actually living in Queensland rivers. Throughout Australia, therefore, we may consider that in desert or sandy regions and eolian or fluviatile deposits has formed or is forming. It hardens into stone in certain portions, and thus gives rise to the precipitous sandstone cliffs and flat-topped mountains which are so characteristic of Australian scenery.

"The Tertiary beds already referred to as covering so large a portion of the south portion of the Continent are apparently divisible into regular horizons similar to those of Europe.

"There is no satisfactory evidence of any former participation in the great ice age by the continent of Australia. One or two instances of grooves or striations are recorded, but standing alone in so vast a territory their ice origin is very doubtful. On the whole the evidence afforded by the animal remains is decidedly in favour of a warmer climate for Australia than that which now prevails, and this is borne out by the plant remains.

"It is generally thought that Australia is a continent quite recently upheaved from the ocean. There is, however, no evidence of such an origin, at least for the whole. The facts of which we can be certain are these :—Since the Miocene period

the southern portion of the Continent, for its whole extent, has been upraised to a height of about 600 feet. Subsequently and contemporaneously there has been a large amount of volcanic disturbance with outpouring of basaltic lavas. After this there has been a subsidence, not very considerable in amount, but extensive. This is to be seen, as Professor Tate has pointed out, by the fringe of eolian calcareous sandstones which, for a short distance out to sea, surrounds the south coast. There has been over a limited area on the south-east side of the Continent a renewal of volcanic activity and slight elevation of the coast. On the east side there is no evidence of upheaval for its whole extent, but there are very decided marks of subsidence in probably Tertiary times. A long fault at the edge of the Blue Mountains near Penrith and for many miles north and south may be a downthrow, which brings the Hawkesbury sandstone nearly to the level of the sea, where it forms the romantic fiords of Port Jackson, Broken Bay, etc. The existence of the Barrier Reef on the north-east coast is also generally regarded as marking a slow period of subsidence. This view is confirmed by the general conformation of the coast line, mountain systems, and islands."

APPENDIX B.—SECTIONS OF STRATA IN THE NEWCASTLE COAL-FIELD.

AUSTRALIAN AGRICULTURAL COMPANY.

An account of strata passed through in No. 10 borehole on the Australian Agricultural Company's Newcastle property between the gasworks and Duffer pit, bored by M. A. Steel, July, 1880. Surface 16·41 feet above high-water mark.

	Ft.	In.
Surface sand	55	0
Clay of various colours	42	0
Gravel and large stones	8	0
Clay, mixed pebbles, and stones	28	7
Post conglomerate	4	0
Post and slate girdles	9	8¾
Post, hard	19	5½
Crusted post ribbed with ironstone..	18	5¾
Post and slate girdles...	13	11
Coal and bands	3	1¼
	19	7¼
Post, very hard	1	1½
	223	0

NEWCASTLE COAL MINING COMPANY, LIMITED.

Section of strata passed through in sinking the B Pit:—

	Ft.	In.
Hard yellow clay	30	0
Yellow clay with a little sand mixture	10	0
Soft clay with boulders	31	6
Coal, very soft	1	6
Blue shale, soft	11	0
Blue shale, soft	36	5
Hard grey post	24	1
Blue shale	1	6
Hard grey post	3	6
Blue shale	5	8
Hard grey post	0	10
Blue metal, rather soft	7	6
Grey post	6	5
Blue metal, rather hard	4	7
Dark blue metal, mixed with sandstone bands	1	1
Coal	1	3
Dark blue shale	1	1
Coal top band	2	10
Coal, big tops	2	8½
Bands	0	1
Coal bottom lifts	1	3
Morgan	0	6
Coal	0	10
Band	0	0½
Coal (little tops)	0	10
Jerry	1	3
Coal bottom	2	3
	190	6

Main seam—

	Ft.	In.
Coal	10	8½
Bands	1	10½
Total	12	7

SCOTTISH AUSTRALIAN MINING COMPANY.

An account of strata and coal seams sunk through at the Durham Colliery (No 1 Pit), near Redhead, in the County of Northumberland:—

Name of Stratum.	Ft.	In.
Sand	54	0
Red rock	6	0
Pebbly stone (soft conglomerate)	3	0
White rock	15	0
Grey shale	13	0
Black streaky rock	5	5
Coal	0	6
Pipe-clay	0	1
Coal	1	7
Carried forward	98	7

Name of Stratum.	Ft.	In.
Brought forward	98	7
Pipe-clay	0	2
Black shale	0	3
Indurated clay	0	7½
Black shale and coal	1	8
Pipe-clay	0	6
Black shale	0	6
Pipe-clay	1	3
Black shale	2	9½
Carried forward	106	4

Name of Stratum.	Ft	In.
Brought forward ...	...106	4
Streaky band	... 0	4
Black shale	... 1	3
Blue shale...	... 10	1
Grey shale	... 4	0
Coal	... 1	1
Blue shale...	... 0	8
Pipe-clay	... 0	4
Foul coal	... 0	7
White shale	... 3	0
Hard blue metal	... 5	3
Grey post	... 6	0
Conglomerate	... 3	9
Dark grey shale	... 6	0
Hard grey post	.. 13	10
Ironstone band	... 0	2
Dark grey metal	... 1	9
Ironstone band	... 0	2
Grey metal	... 3	9
Basaltic rib	... 0	2
Grey post	... 9	4
Brown rock	... 2	0
Black streaky shale ...	... 3	8
Hard blue streaky shale...	... 6	0
Blue shale, with ironstone	... 4	4
Pipe-clay	... 0	0½
Coal	... 0	8½
Dark shale	... 0	5
Coal	... 0	4
Dark shale	... 0	4
Coal	... 0	6
Pipe-clay	... 0	0½
Coal	... 1	2
Pipe-clay	... 0	0½
Coal	... 1	7
Pipe-clay	... 0	5
Coal	... 0	8
Fire-clay	... 0	4
Coal	... 3	8
Pipe-clay	... 0	3
Coal	... 1	3
White rock	... 0	11
Blue shale...	... 1	5
White rock	... 2	0
Dark shale	... 3	1
White rock	... 3	6½
Grey shale	... 1	2
Dark blue shale	... 4	6
Carried forward ...	...223	9½

Name of Stratum.	Ft.	In.
Brought forward ...	...223	9½
Grey metal	... 1	2
Grey post	... 37	8
Light hard shale and ironstone	... 9	9
Band, with coal pipes ...	... 0	11
Coal	... 0	6
Band, with coal pipes ...	... 0	4
Coal	... 0	6
Band	... 0	1
Coal	... 0	6
Band and coal pipes ...	... 1	0
Chert	.. 0	6
Grey post	... 8	6
Dark shale	... 2	6
Coal and jerry	... 0	4
Dirty coal...	... 1	10
Jerry band	... 0	2
Coal	... 1	6
Indurated clay	... 0	3
Coal	... 0	2½
Pipe-clay	... 0	0½
Coal	.. 1	4
Dark shale	... 0	8
Coal	... 0	2
Pipe-clay	... 0	1
Coal and bands	... 0	7
Light grey post	... 1	0
Dark shale	... 0	8
Dark grey post	... 0	8
Blue shale and sandstone and ironstone bands ...	... 26	3
Coal	... 0	10
Blue shale...	... 0	6
Grey post and shale ...	... 1	11
Coal	... 1	3
Dark shale	... 2	6
Grey metal	... 0	4
Conglomerate	... 25	0
Post and shale	... 3	6
Freestone	... 2	6
Black shale	... 6	0
Freestone and shale ...	... 4	6
Post and shale	... 32	0
Grey post	... 3	6
Dark shale and ironstone	... 4	6
Grey post	... 1	1
Shale and ironstone ...	... 0	8
Grey post	. 1	9
Carried forward ...	...416	0½

Name of Stratum.	Ft.	In.
Brought forward ...	...416	0½
Dark shale	... 7	0
BOREHOLE COAL SEAM—		
Bituminous shale ...	... 1	0
Pipe-clay band ...	... 0	0½
Bituminous shale ...	... 0	8
Pipe-clay band ...	... 0	0½
Bituminous shale ...	... 1	0
Dark shale	... 0	8
Good coal	... 2	2
Band	... 0	0½
Carried forward ...	...428	7½

Name of Stratum.	Ft	In.
Brought forward ...	...428	7½
BOREHOLE COAL SEAM—		
Good coal	... 1	11
Band	... 0	0½
Good coal	... 1	3
Morgan	... 1	0
Good coal	... 0	4
Coal and jerry, mixed ..	4	0
Dark grey shale	... 2	6
Grey post	... 22	0
Total depth sunk ...	...461	8

NORTHUMBERLAND COAL MINING COMPANY.

An account of strata and coal seams sunk through near Teralba:—

Name of Stratum.	Ft.	In.
Chert	29	0
Black shale and fire-clay bands ...	2	11
Black shale...	3	0
Black shale and fire-clay bands ...	0	5
Coal	0	6
Fire-clay	0	1
Coal	1	2
Coal	0	9
Fire-clay	0	2
Coal and shale	2	3
Fire-clay	0	2
Coal and shale	2	3
Black shale and fire-clay bands ...	5	7
Coal and shale	3	9
Fire-clay	0	9
Coal	2	3
Grey metal...	3	5
Post girdle	0	4
Grey metal...	5	2
Fire-clay	0	9
Post	6	3
Fire-clay	1	3
Coarse conglomerate	10	0
Fine conglomerate	5	4
Conglomerate	96	8
Fine conglomerate	5	0
Post	1	3
Conglomerate	11	3
Dark grey post	3	0
Carried forward ...	...204	8

Name of Stratum.	Ft.	In.
Brought forward ...	...204	8
Conglomerate	13	10
Grey post	6	2
Blue shale	0	2
Grey post	5	8
Hard flinty post	5	0
Black shale...	0	7
Grey metal...	2	1
Hard post	22	6
Chert	9	6
Coal, shale, and fire-clay bands ...	2	8
Post	0	3
Coal, shale, and fire-clay bands ...	0	6
Hard dark post	1	10
Chert	2	6
Coal and shale	1	6
Chert	0	6
Coal	1	4
Black shale	1	4
Fire-clay	0	1
Black shale and ironstone ...	6	3
Grey metal...	31	6
Black shale...	0	11
Coal...	1	0
Black shale...	0	9
Grey metal...	1	6
Coal and shale	4	4
Brown fire-clay	0	5
Black shale	0	8
Carried forward ...	... 330	0

Name of Stratum.	Ft.	In.
Brought forward ...	...330	0
Grey metal...	0	1
Black shale	1	0
Grey metal	2	6
Black shale	0	8
Coal...	0	11
Black shale	0	6
Coal...	2	0
Post...	0	4
Black shale	0	5
Grey metal...	2	2
Black shale	0	6
Coal	0	6
Black shale, with grey metal band	3	10
Hard post	50	0
Black shale	0	9
Coal	1	0
Fire-clay	0	6
Coal...	1	10
Black shale	0	8
Grey metal	13	6
Carried forward ...	...413	8

Name of Stratum.	Ft.	In.
Brought forward ...	...413	8
Black shale	0	5
Coal	0	6
Black shale	0	2
Blue metal	4	6
Post, with blue metal post girdles	6	8
Blue metal	0	2
Black shale	0	2
Coal	0	5
Fire-clay	0	1
Blue metal and post girdles ...	5	6
Blue metal	5	6
Grey metal	0	6
Black shale	0	2
Grey metal	0	2
Coal and black shale ...	1	0
Fire-clay	0	0½
Coal and black shale ...	3	0
Grey metal	0	1
Coal	0	6
Post and fine conglomerate ...	33	0
	476	2½

Teralba Coal Company.

An account of strata and coal seams sunk through on Black's 2,560 acres of land at Cockle Creek, near the Sydney and Newcastle Railway, Teralba:—

Name of Stratum.	Ft.	In.
Soil and gravel	6	0
Clay	4	0
Sandstone and clay bands	5	6
Blue metal	0	11
Grey metal	1	6
Sandstone...	22	4
Shale and coal bands ...	9	2
Bastard post	3	0
Coal, with bands... ...	0	9½
Pipeclay—water	0	4½
Coal and bands	1	8
Pipe-clay	2	4½
Coal, with bands... ...	2	6
Post	6	10
Slate	0	2
Clean coal...	1	10
Chalky rock	1	9
Grey metal	1	1
Post	2	10
Carried forward ...	... 74	7½

Name of Stratum.	Ft.	In.
Brought forward ...	... 74	7½
Grey metal	5	2½
Freestone	5	11
Grey metal post	3	4
Sandstone...	14	0
Black metal	0	11
Grey metal	1	9
Post and sandstone ...	5	4½
Grey metal	0	11
Pipe-clay and chert ...	2	11
Black shale and coal ...	1	4
Pipe-clay and chert ...	0	8
Black shale and coal ...	1	10
Pipe-clay and chert ...	1	10
Black shale and coal bands ...	1	9
Coal and bands	1	2
Blue metal, with Glossopteris ...	3	10
Clean coal...	1	2
Band	0	0½
Carried forward ...	...128	7

Name of Stratum.	Ft.	In.
Brought forward ...	...128	7
Clean coal	... 1	0
Black shale band... ...	... 0	2½
Clean coal...	... 0	7½
Band	... 0	0½
Coal	... 0	1
Stone band	... 0	0½
Coal	... 0	7½
Blue shale...	... 0	2
Grey metal	... 0	11
Grey post	... 2	1½
Grey, dark, and grey metal	... 3	7
White post, with Glossopteris	... 6	0
Ironstone band	... 0	6
Blue shale	... 0	6
Grey metal	... 3	0
Grey post	... 4	0
White post	... 19	10½
Fire-clay	... 0	7
Chert	... 3	4½
Black band	... 0	2
Good coal...	... 0	9
Grey metal, with post beds	... 5	2
Post	... 0	5½
Grey metal	... 0	3
Post	... 2	4
Good coal	... 0	9
Blue shale, with Glossopteris	... 4	10
Post	... 2	0
Grey metal and blue shale	... 1	10½
Post	... 1	10
Blue metal	... 0	6
Post	... 0	10
Grey metal	... 1	1
Post, with fossils... ...	... 0	4
Blue and grey metal ...	... 7	1
Blue shale	... 0	7
Coal	... 0	7
Fire-clay	... 0	1½
Blue shale...	... 0	1½
Fire-clay	... 1	10
Coal—good	... 0	3½
Fire-clay	... 0	2
Coal—good	... 0	3
Stone band	... 0	0½
Coal and bands	... 0	4
Coal—good	... 1	0
Stone band	... 0	1
Carried forward ...	...211	5½

Name of Stratum.	Ft.	In.
Brought forward ...	...211	5½
Coal and bands	... 0	4
Coal—good	... 0	3½
Stone band	... 0	2
Coal—good	... 0	10
Hard black shale, with Glossopteris	... 8	0
Coal	... 1	0
Coarse coal, with shale bands ...	... 2	5
Fire-clay	... 0	1
Black shale	... 0	2½
White chert	... 10	0
Whinstone	... 0	9
Felspar and greenstone mixed ..	... 0	9½
Black shale—fossiliferous ...	... 4	5½
Iron bands	... 0	5
Blue shale...	... 2	0
Post rock	... 2	0
Grey shale and post	... 2	10½
Grey metal	... 0	7½
Grey shale	... 0	1
Post	... 1	7½
Grey shale	... 0	3
Post	... 0	6
Grey shale	... 0	11
Grey whinstone	... 5	1
Leafy post	... 1	1
Grey shale	... 0	9
Post	... 0	6
Blue shale...	... 4	0
Blue shale (slaty and stratified)..	... 10	11
Blue shale...	... 4	0
Blue shale (soft)	... 1	10
Shale and chert	... 2	4
Blue shale...	... 5	2
Chert	... 4	2
Bituminous shale	... 4	2
Shale and fire-clay	... 6	0
Coal	... 1	3
Black shale	... 0	11
Fire-clay	... 0	5
Black shale	... 0	6
Fire-clay	... 0	5
Black shale	... 0	6
Fire-clay	... 0	1
Coal	... 1	0
Fire-clay	... 0	4
Coal	... 1	2
Carried forward ...	...308	8

Name of Stratum.	Ft.	In.
Brought forward ...	...308	8
Fire-clay	1	0
Coal and bands	4	11¼
Black shale	0	2
Chert	0	4
Dirty coal...	0	7½
Chert	0	9
Coal and bands	2	3½
Chert	3	10
Post	3	0¼
Black shale	0	2
Coal	0	10¼
Band	0	0¼
Coal	0	2¾
Chert	1	2½
Coal	0	7½
Band	0	0¼
Coal	0	9½
Chert band	0	1
Coal	0	11
Chert band	0	4
Coal (dirty)	1	3½
Black shale and coal bands	2	8½
Chert band	0	0¾
Black shale	0	9
Chert	0	5
Black shale	0	3½
Coal (clean)	0	9
Post	0	4
Chert	1	8½
Black shale	0	8
Chert	2	4
Post	5	9
Carried forward ...	...348	0¼

Name of Stratum.	Ft.	In.
Brought forward ...	...348	0¼
Hard black shale... ...	1	7½
Fire-clay	0	4½
Coal	1	1
Band	0	0½
Coal	0	2
Band	0	1
Coal	0	7½
Band	0	0½
Coal and bands	0	8½
Fire-clay	0	3
Coal	0	10½
Band	0	1
Coal	1	1
Stone band	0	0½
Coal	0	1
Stone band	0	1½
Coal	1	4
Stone band	0	1
Black shale	1	3½
Dark grey post	0	10
Grey post	9	7
Gritstone	0	10
Grey post and gritstone...	11	3
Chert	2	5
Flintstone...	2	2
Grey shale (metal) ...	6	4
Blue shale and ironstone ..	1	0
Post with fossils	7	0
Chert and post, with ironstone bands	7	0
Chert	14	0
	420	3¼

APPENDIX C.

SYNOPSIS OF VEND AGREEMENT OF NEWCASTLE COLLIERIES, DATED 12TH FEBRUARY, 1891.

Companies Associated—Australian Agricultural, Newcastle Wallsend, Scottish Australian Mining Company, Co-operative Collieries, Newcastle Coal Mining Company, Ferndale Collieries, Burwood Coal Mining Company, and Greta Collieries.

Objects of Association.—For the purpose of preventing fluctuations in trade and prices, and liability to strikes and lock-outs, and loss therefrom, owing to want of united action, and generally to promote the interests of the signatories.

Agreement for three years from February 12th, 1891. Each of the parties, corporate or individual, covenant with the trustees:

1. As to the definition of the following terms:—"Member," "Association," "Board," "Executive Committee," "Original Member," "New Member," "General Fund," "Trustees."

2. Agreement for three years.

3. The *General Fund*, namely, £42,347 to be retained by bankers.

4. Each party to nominate representatives in writing.

5. *Nomination of Representatives.*—The board of members may act notwithstanding any vacancy by failure to appoint. The total number of votes shall be 100, or such other number as the board may from time to time determine, and each representative shall have a number of votes bearing such proportion, to the total as the estimated proportion for the time being, for the colliery represented by him bears to the total trade for the current year, to the entire body of members. The chairman shall vote as an ordinary member, and shall likewise have a casting vote in case of equality of votes on any motion or resolution.

6. A quorum to consist of representatives entitled to give not less than sixty per cent. of the entire votes of the board. The board to have entire control over its own procedure. The chairman or secretary may at any time convene a meeting.

7. The board may appoint from its own members the executive committee, consisting of such number of members as the board shall think fit.

8. The voting powers of the members of the executive committee shall be of equal value. Questions shall be decided by a majority of votes. The chairman to have a casting vote.

9. In addition to any matters specially provided for, the board shall have cognizance of all matters in any way affecting the trade or interests of the association or any member thereof, and the members are bound faithfully to observe and carry out any resolution or decision declaring the necessity of united action among the members, or fixing the course of action to be pursued by them, or any of them. Provided that if any such resolution or decision be likely to lead to a general strike of miners, top-men, engine drivers, horse-drivers or other employees above or below ground, such resolution or decision shall be of no effect unless carried by a majority consisting of not less than four-fifths of the total voting power of all the members of the association, provided that if there be one dissentient only or if one representative shall be absent or abstain from voting, the resolution be considered as carried, although the dissenting, absent, or neutral member be entitled to a fifth or more of the voting power of the whole association. Any resolution or decision requiring a four-fifths majority can only be rescinded or altered by a like majority.

10. The board shall appoint a chairman and a secretary, or remove them, or appoint a successor in case of vacancy of any office.

11. The board may pay such salary or remuneration to any officer as it may consider reasonable.

12. The board shall have power from time to time to call on the members to contribute a sum not exceeding £100 for each 1 per cent. of trade, either in one sum or periodically, to the fund already established, or to any fund which the board may think it desirable to es tablish for the purposes stated. The sum called for by the board from time to time shall be apportioned among the members in proportion to the shares of trade for the time being allotted to them respectively.

13. Power to sue for contributions, with interest at 8 per cent.

14. Continuance of existing officers.

15. The board to have absolute and distinct control of any general fund or any special fund raised under the agreement, and may dispose of them at their absolute discretion. Any unexpended balance to be apportioned to the contributors *pro rata* at the termination of the agreement, but no member who shall have retired, or has been expelled from the association, to have any claim.

16. The board may affiliate with any kindred, or any other association or associations, and may use the funds for the purposes of the combined associations.

17. For the year 1891 the estimated share of each of the original members in the aggregate trade of the association shall be as follows:—

	Per Cent.
Australian Agricultural Company	18·82
Newcastle Wallsend Coal Company	24·82
Scottish Australian Company	12·62
Co-operative Collieries	10·94
Newcastle Coal Company	12·01
Ferndale Collieries	2·90
Burwood Coal Company	9·67
Greta Collieries	8·22
Total	100·00

18. At the beginning of the year 1892, and of each subsequent year, a fresh estimation of the proportions of trade of each colliery belonging to several members, and the aggregate trade of the association for the then ensuing year, shall be made, and shall be arrived at as follows:—Each colliery, the actual trade of which for any year shall equal the proportion allotted to it for that year, shall have for the succeeding year the same proportion allotted. Each colliery which exceeds the proportion allotted to it shall retain such proportion, with the addition of one-third of the excess of its trade, and each colliery which produces less than its proportion, shall take for the ensuing year such proportion less one-third of the deficiency. In the case of any new member, his actual trade for the first year shall be considered as having been allotted to him for that year.

19. In estimating the proportion of trade in the various collieries for any year, screened and unscreened and small coal shall be counted alike ton for ton.

20. The Board shall from time to time fix and determine the prices of screened, unscreened, and small coal, for the produce of the mines belonging to and worked

by parties to this agreement; such prices shall be the same for all the collieries, and for all purchasers alike irrespective of the quantity sold.

21. Members bound only to dispose of coal at the prices fixed, except in the case of *bona-fide* contracts entered into by new members prior to their entrance, and disclosed to the association. No commission in excess of 2½ per cent. must be allowed on any sale of coal, and no agent must be employed in the United Kingdom, or in any other place outside the Australian Colonies, at a salary exceeding £200 a year, unless the commission of 2½ per cent. on the actual sales would amount to a larger sum. The board have power to make special exceptions when the circumstances appear to warrant it.

22. An allowance in weight of coal for waste may be made for intercolonial trade, to the extent of 1 per cent., and for foreign trade, to the extent of 2 per cent.

23. Members may dispose of the produce of their respective quantities without restriction as to quantity, but any member exceeding his allowance must pay on each ton in excess to the vend fund, if the selling price is 12s. or over, 3s. 6d. a ton, if the price is less than 12s., as follows:—

				Per Ton.
Under 12s. 0d.	but not more than	11s. 6d.	... ...	3s. 3d.
„ 11s. 6d.	„	„ 11s. 0d.	... ...	3s. 0d.
„ 11s. 0d.	„	„ 10s. 6d.	... ...	2s. 9d.
„ 10s. 6d.	„	„ 10s. 0d.	... ...	2s. 6d.
„ 10s. 0d.	„	„ 9s. 6d.	... ...	2s. 3d.
„ 9s. 6d.	„	„ 9s. 0d.	... ...	2s. 0d.
„ 9s. 0d.	„	„ 8s. 6d.	... ...	1s. 9d.
„ 8s. 6d.	„	„ 8s. 0d.	... ...	1s. 6d.
„ 8s. 0d.	„	„ 7s. 6d.	... ...	1s. 3d.
„ 7s. 6d.	„	„	... ...	1s. 0d.

and collieries which do not work up to their allowance will receive from the vend fund the same amount per ton of deficiency. Collection and distribution of the vend fund to be in the hands of the secretary and payment to be quarterly.

24. Each member, within three days of the end of each month, to furnish the secretary with a true and faithful return of all the coal invoiced or supplied since the date of the last return, and the secretary, within one week thereof, to furnish to each of the members a summary of the quantity of such sales, showing the excess or deficiency of such sales of each member, if any.

25. Within ten days of the end of each quarter the secretary to furnish to each member a summary of the sales for that quarter, and a statement showing the amounts payable to and received from the vend fund to or by all of the parties to the agreement, and such statement shall be laid before the board at their first meeting after the end of each quarter; and the statement being approved by the board, any sums payable to the vend fund shall within three days of such approval be paid by the parties liable to the extent of one-half to the parties entitled to receive compensation, the other half being retained by the treasurer until the final settlement for the year.

26. The secretary to lay before the board a statement showing the excess and deficiency sales of each member for any year, and the payments made in respect thereof during the year, and the amount which may be due or may have been overpaid in respect of the gross deficiency or excess. Provided that in making up such statement, no party or colliery shall be entitled to compensation on more than one-fifth of their allotted proportions of the trade for the year then expired. Any surplus or balance of the vend fund for the year shall be divided among the collieries contributing on their excess sales in the proportion of their contributions, but it is competent for the board by special resolution to direct payment of compensation for the whole or any greater part than one-fifth for the proportion of trade of any member, when in their opinion circumstances justify such payment.

27. In cases of dispute between collieries and their workmen, the association may support members, provided they act in accordance with the advice of the board.

28. The board may grant to members affected by strikes such assistance out of the vend fund as they may think proper.

29. Provided that if a member shall, after the executive committee or the board has assumed the management of a dispute, take the matter out of their hands and act contrary to their advice and direction, such member shall lose any right to receive any such compensation.

30. If any member prefers to conduct a dispute without the assistance of the board, or if the board declines to interfere, and if the member succeeds in obtaining an object which the board think is an advantage to the collieries generally, they may grant to such member such sum from the vend fund as they may think fit.

31. All claims on the general fund or special funds arising out of any such dispute as mentioned in the four preceding paragraphs shall be entitled to priority of payment in the order of the settlement of the dispute in respect of which they may arise.

32. Assignment of interests.

33. Admission of new members.

34. Proper books of account showing, amongst other things, the sums contributed to the general fund, and the compensation paid or authorized to be paid therefrom, to be kept.

35. An annual meeting to be convened in January of each year, at which meeting a report of the proceedings of the past year shall be submitted, and duly audited accounts presented, together with the account relating to the vend fund. Meetings may be convened at any other time by the executive committee, or any two of them, or by any three of them, by giving not less than one month's notice in writing stating the object of the meeting.

36. The board may from time to time add to or rescind, alter or amend any of the provisions or clauses of this agreement.

37. Power to expel members who may have acted prejudicially to the interests of the association. Any member expelled from the association shall lose all claim

to or interest in the general fund, or any special fund created, but no member may be expelled except by a majority equal to 75 per cent. of the total number of votes of the board given at a meeting specially convened for the purpose, of which not less than thirty days' previous notice must be given. At such meeting the member whose conduct is under consideration shall be allowed to vote, but in ascertaining the percentage above referred to the total number of votes shall be taken without counting his vote. The board may rescind any resolution to expel a member or may re-admit any member expelled.

38. The association shall be called the "Association of Northern Collieries, 1891."

39. The agreement may be put an end to by effluxion of time in some or one of the following modes:—

Firstly as regards any individual member—

(*a*) By his or their giving three calendar months' notice to that effect, terminating and ending 31st day of December. The member giving such notice shall forfeit all claims on the general fund or any special fund raised under the provisions of the agreement.

(*b*) By his or their proving to the satisfaction of the board that any other party to the agreement has been committing any substantial breach of this agreement, and by giving notice of intention to retire within one week of the decision of the board. A party so retiring shall be entitled to a proportion of the contribution from the vend fund in respect of any deficiency of sales made by him or them up to the expiration of the notice, and shall, at the final distribution of the general fund or any special fund to which he or they may have contributed, be entitled to a share in the balance, to be distributed in the same proportion as he or they may have contributed thereto.

Secondly as regards the whole of the parties to this agreement—

(*a*) Where any party has been proved to the satisfaction of the board to have been underselling or to have committed any other substantial breach of this agreement, and the board shall have decided to terminate the agreement, such termination may take place by resolution to that effect within thirty days from the date of the resolution.

(*b*) When the board shall so determine by the vote of the majority equal to 75 per cent. of the voting power actually present at any meeting specially convened for that purpose.

APPENDIX D.

NEW SOUTH WALES MINING ACT, DIVISION III.

Mineral Leases and Licenses.—Clauses 56 to 63.

The Governor may grant leases of any Crown land for the purposes of mining for any metal or mineral other than gold, subject to the following conditions. And

upon the granting of any such lease, any lease for pastoral purposes which may have been granted or promised under the Crown Lands Occupation Act of 1861, inclusive of the same land, or any part thereof, shall, as respects such land, absolutely cease and determine :—

(1). The area in any lease shall not exceed six hundred and forty acres for coal mining lots, and shall not exceed eighty acres for other mineral lots.

(2). Leases may be for any period not exceeding twenty years, but may be renewed for a further period not exceeding twenty years.

(3). Applications for leases may be made at such times and places and in such form as may be prescribed by any regulations hereunder to the warden, if the land be within a mining district, or if otherwise to the land agent of the district or other officers authorized in that behalf by any such regulation, and shall set forth a clear description of the lots proposed to be leased, and of the boundary marks or natural features by which the same are to be identified. And the applicants may forthwith take possession of such lots. Provided always that the right shall be reserved to the Minister for Lands to determine the boundaries of all such lots, and to make provision for the preservation of water supply or access thereto, and for such other reservations as he may deem necessary for the public interests.

(4). Applications for leases hereunder shall be entitled to precedence in the order of their receipt by the warden, or land agent, or other authorized officer.

(5). The rent shall be five shillings per acre, payable annually in advance, the first payment to be made at the time of making the application, which shall cover the rent for one year from the granting thereof, and the rent for each ensuing year, or such part thereof as may be proportioned the period between the granting of the application and the 31st December, to be paid to the Colonial Treasurer in Sydney not later than the month of November of the year preceding, and in default of any such payment the lease shall be forfeited.

(6). Leases shall in all cases terminate on 31st December.

(7). Lessees shall expend at the rate of five pounds sterling per acre on their lots within the first three years of the lease.

(8). Lessees may determine their leases by giving to the Minister three months notice of their desire to do so, but no rent shall in any such case be refunded.

(9). Lessees may, on application to the Secretary for Mines, in writing, during the nineteenth year of their leases, obtain a renewal of the same for a further period not exceeding twenty years, and the fine to be paid on such renewal, not being less than two pounds ten shillings per acre, shall be determined in such manner as may be provided by any regulation

hereunder, and full information of the working and returns of the mine shall be afforded to the Secretary for Mines by the lessees, on pain of forfeiting their claim to renewal.

(10). If any lease be forfeited and not renewed, the lessee shall be at liberty, within six months from the termination of his lease, to remove or otherwise dispose of all machinery and improvements and the minerals brought to the surface during the term of his lease.

(11). On the breach by the lessee of any condition of a lease the Governor may direct the cancellation of such lease.

In the event of a dispute arising as to the right to any lease it shall be lawful for the Secretary for Mines to authorize and direct some competent officer to make enquiry into such dispute, and to take such other proceedings in relation thereto as are authorized by this Act to be taken by the warden in an enquiry into the right to a lease for gold mining; and the several provisions of the said sections shall, so far as the same are applicable, be held to apply to any enquiry hereunder.

On its being made to appear that the property in dispute is liable to be prejudiced by the working of the minerals therein, pending such enquiry, the Secretary of Mines may issue and cause to be served upon either party, or posted in some conspicuous place on the land in dispute, his injunction for the suspension of all mining operations and workings on the said land until the right to a lease of such land shall have been duly enquired into and determined in favour of either party as herein provided, or until such injunction shall have been withdrawn or otherwise lawfully set aside; and any person who shall wilfully or knowingly disregard and disobey any such injunction by working for, or removing, or otherwise interfering with the minerals on the said land, contrary to the intent and purport thereof, shall for the first such offence forfeit a sum not exceeding fifty pounds sterling, and for any second or succeeding offence shall forfeit a sum not exceeding fifty pounds sterling for every day during which such minerals shall have been so worked for, removed, or otherwise interfered with; and such penalties may be recovered in a summary way before any two or more justices in petty sessions, and in default of payment of any penalty adjudged by them such justices may commit the offender to some gaol or house of correction for any period not exceeding twelve calendar months.

The Governor may make and proclaim regulations for carrying this division of the Act into full effect so as to provide for all proceedings, forms of leases, and other instruments for the working of mineral lots, for the issue of injunctions prohibiting the working of minerals on such lots, pending any dispute or enquiry, for the cutting of water-races through leased land, for fixing the days upon which mineral selections shall be made, and all other matters and things arising under and consistent with the provisions of this Act and not herein expressly provided for. And all such regulations shall, upon publication in the *Gazette*, be valid in law, provided that copies of every such regulation shall be laid before both Houses of

Parliament within one month from the issue thereof, if Parliament be then in session, or otherwise within one month after the commencement of the then next ensuing session.

In any case in which it shall be made to appear to the satisfaction of the Secretary for Mines that greater facilities for the working of adjoining mineral lots would be ensured by the amalgamation of such lots, it shall be lawful for him to authorize such amalgamation upon the payment of a fee not exceeding twenty shillings for each lot so to be amalgamated, and the provision as to expenditure on mineral lots hereinbefore contained shall apply to such lots when so amalgamated, and for the purposes of this section the word "lots" shall be taken to include as well land under mineral lease as land applied to be leased under section 56 hereof, or under the Act hereby repealed.

Every person who shall have obtained a mineral lease under this or any other Act, and who shall desire to mine in the land demised by such lease for any minera or metal other than that for the mining of which such lease shall have been granted, shall give notice of such his desire to the Secretary for Mines. And if any such person shall proceed to mine for any such other mineral or metal without having obtained due authority so to do as hereinafter mentioned he shall be liable to a forfeiture, and cancellation of his lease as for a breach of condition.

Where gold is associated or combined with any other mineral or metal in any land demised under this or any other Act, if the lessee shall desire to mine for such gold, or should the nature of the mining operations be such as to lead to the removal of such gold, such lessee shall make application for a gold mining lease of the said land to the said Secretary for Mines under the provisions of this Act, in addition to any mineral lease which he may hold. And if such lessee shall proceed to mine for such gold before he shall have obtained such gold mining lease his mineral lease shall be liable to be forfeited and cancelled as aforesaid.

It shall be lawful for the Governor to cause documents to be called "Mineral licenses" to be issued to any person or persons applying for the same, and upon payment of the sum of twenty shillings for each such license. Every such mineral license shall be in force for the period of twelve months from the date thereof, and shall during the said period confer on the holder thereof the same rights and privileges in respect or in connexion with mining for minerals other than gold, as are declared by this Act to be conferred on holders of miners' rights in respect of mining for gold.

APPENDIX E.

COPY OF ENGAGEMENT RULES.—ILLAWARRA DISTRICT.

RULES OF EMPLOYMENT, AND RATES FOR HEWING COAL, AND YARDAGE, ETC., AT THE BULLI COLLIERY.

Engagement.

1. All persons accepting engagement in or about Bulli Colliery, shall do so subject to the following rules, rates, and conditions, and also to the general and

special rules approved by the executive council, of which a copy shall be supplied to each employee on attaching his signature hereto, and shall be bound hereby and thereby.

Time of Labour.

2. Except in case of sickness, or some cause which the colliery manager can accept as sufficient, miners, or other employees shall, if required, work regularly eleven (11) full days of not over nine working hours each (unless specially and mutually arranged) in every fortnight or pay. Any employee absenting himself from work without giving a sufficient reason, will be liable to dismissal without notice, and to prosecution for breach of agreement under the Masters and Servants Act.

Absence from regular duties.

3. Any miner or other employee found in any part of the mine other than that in which he should be working, without the consent of the colliery manager, shall be liable to dismissal without notice.

Notice from and to Employees.

4. Every miner or other employee shall give to the colliery manager fourteen (14) days' notice before leaving the company's employment, or absenting himself from work for more than two (2) days (not necessarily consecutive) during any fortnight, unless leave has been granted; and on the other hand, except as otherwise provided, for infringement of rules, every employee shall receive fourteen (14) days' notice before his employment can be terminated by the colliery manager. Any employee leaving without giving due notice shall forfeit any wages then standing in his name.

Control.

5. The colliery manager shall have full command over all employees in or about this colliery. They shall apply to, and take their orders and instructions from him or such other person as may be appointed to act on his behalf.

Interference by Employees.

6. Any employee interfering in any way with the orders issued by the colliery manager or his overman for regulating the work of the mine shall be liable to dismissal without notice.

Right to enter mine.

7. No person other than those immediately connected with the mine shall be allowed on any pretext whatever to enter the same, unless by written consent of the colliery manager.

Pay day.

8. The pay day shall be on a Saturday in each fortnight as heretofore.

Hewing rates, yardage, etc.

9. The rates for hewing coal, compensation for yard work, turning-off bords, and small coal which cannot be thrown back, shall be as follows:—

Bulli Seam.	s.	d.	
Hewing (screened) coal	2	4	per ton.
Extra where Davy lamps are used...	0	3	„
Driving headings 6 feet wide	3	8	per yard.
Turning-off bords, from 2 yards to 8 yards ...	8	0	per bord.
Small coal	0	9	per skip.
4-feet Seam.			
Hewing (screened) coal	2	10	per ton.
Driving headings 6 feet wide	3	3	per yard.
Driving headings 9 feet wide	2	6	„
Driving headings 12 feet wide	1	6	„
Small coal	0	8	per skip.

Day or other wages.

10. Rates of day or other wages not specified in the foregoing shall be as per arrangement made at time of engagement and set forth on this sheet, and initialled by the colliery manager.

Wheeling and prop-cutting.

11. The hewer or hewers in each bord shall wheel his or their full or empty skips any distance not exceeding 50 yards from the working face free of any expense to the company. The hewer or hewers shall set the necessary props, lay the rail after the turn is laid, and keep his place secure from the spot where he commences such place after balloting to the face of coal, and before leaving that place at following ballot.

Partners at work.

12. Unless otherwise arranged, each working place shall be occupied by two hewers, who will be considered to work as partners during the term of cavil. The signature of either partner shall be a full and sufficient discharge for wages due by the company to both parties. Any miner who for good and sufficient reason suspects the integrity of his partner, will so far as is possible be protected by the colliery manager, on the latter receiving in good time a written order to retain his half of the pay due to both.

The turn.

13. The colliery manager and overman alone shall have control of the turn, and any other person or persons interfering with the turn shall be liable for breach of agreement.

House or land rent.

14. The colliery manager shall deduct from the pay of each employee the rent of any house or land belonging to the company, and occupied by the employee.

Doctor's fees.

15. The colliery manager shall have the right to deduct from each pay, employees' levies for their doctor or benefit societies, and his responsibility shall cease upon handing over the sum so deducted to the doctor, or to the secretary or treasurer of such benefit society, as the case may be.

Fire coal.

16. The colliery manager shall have power to deduct from an employee's pay the amount due by such employee for fire coal supplied.

Breach of rules.

17. A copy of the foregoing rules, and also the general and special rules referred to therein, shall be fixed up in the office at this colliery, and any and every employee subscribing hereto shall be liable for each breach by action at law.

By order of the board,

.....

Colliery Manager.

.....188...

I, the undersigned, hereby agree to accept employment from the Bulli Coal Mining Company upon and subject to the rates, conditions, and rules above referred to.

....

....

Addenda to Rule 9.

N.B.—The above hewing rates, etc., have been fixed on an average selling price of 11s. 10d. per ton, and such shall be declared average price for January and July, 1887. Not later than 15th January and July in each succeeding year, the associated collieries shall determine what has been the average selling price for the previous half-year, which shall be declared, and the hewing and yardage rates shall be thereby fixed for the then current half-year.

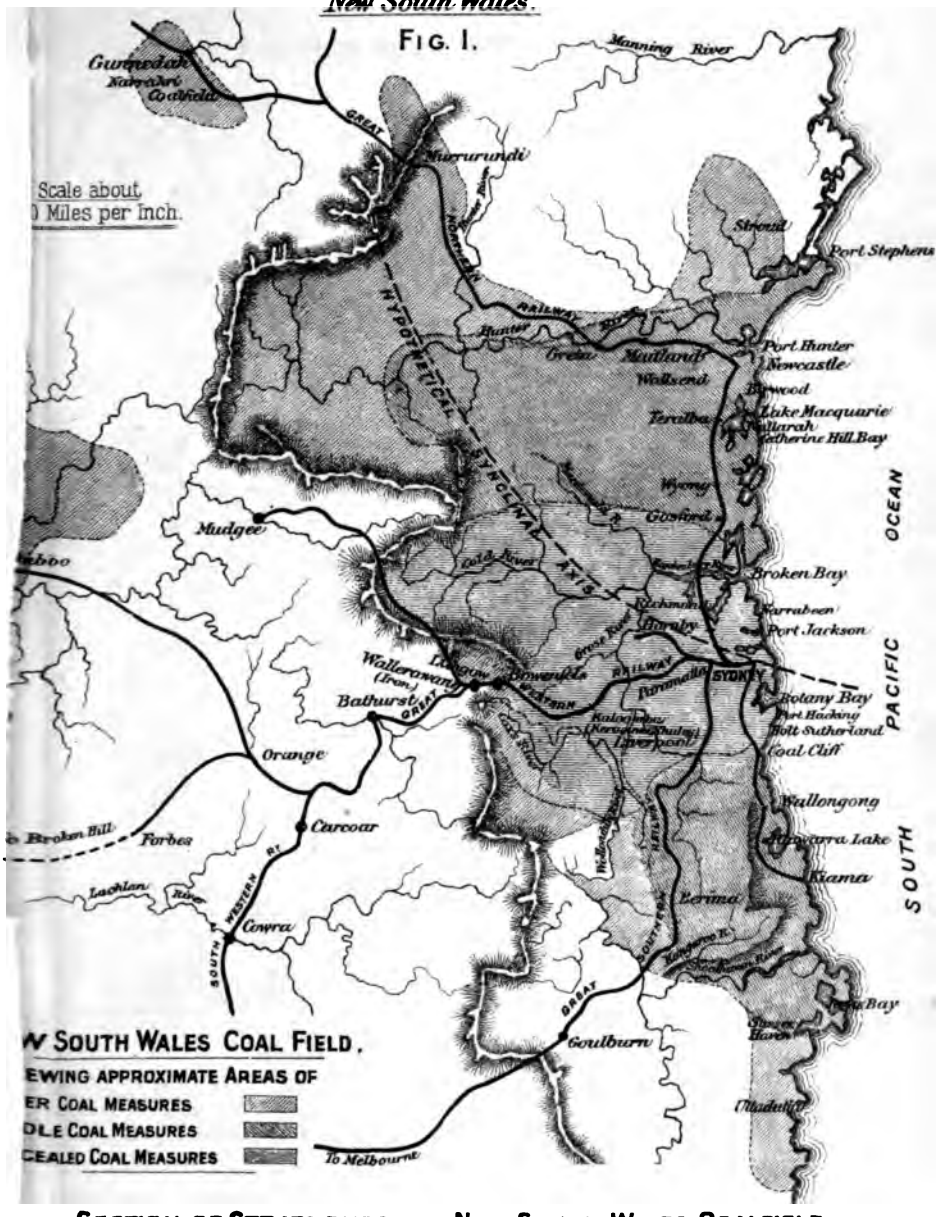
An additional 1d. per ton on the hewing rates, and an additional 1d. per yard on the yardage will be paid to the miners, for every 4d. per ton advance in the price of coal above 11s. 10d., and 1d. per ton and 1d. per yard reduction shall be made for every 4d., the average price is reduced below 11s. 10d.

The PRESIDENT said that as the next paper referred to the same district as that by Mr. Walker, it might be well to hear it, and then take the discussion on both together.

Mr. COX read his paper on "The Coal-fields of Australasia."

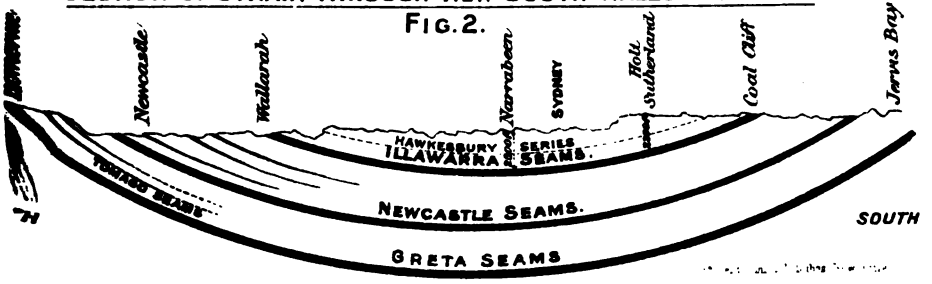
To illustrate Mr. George Blake Walker's "Notes on the Coal-Fields of New South Wales."

FIG. 1.

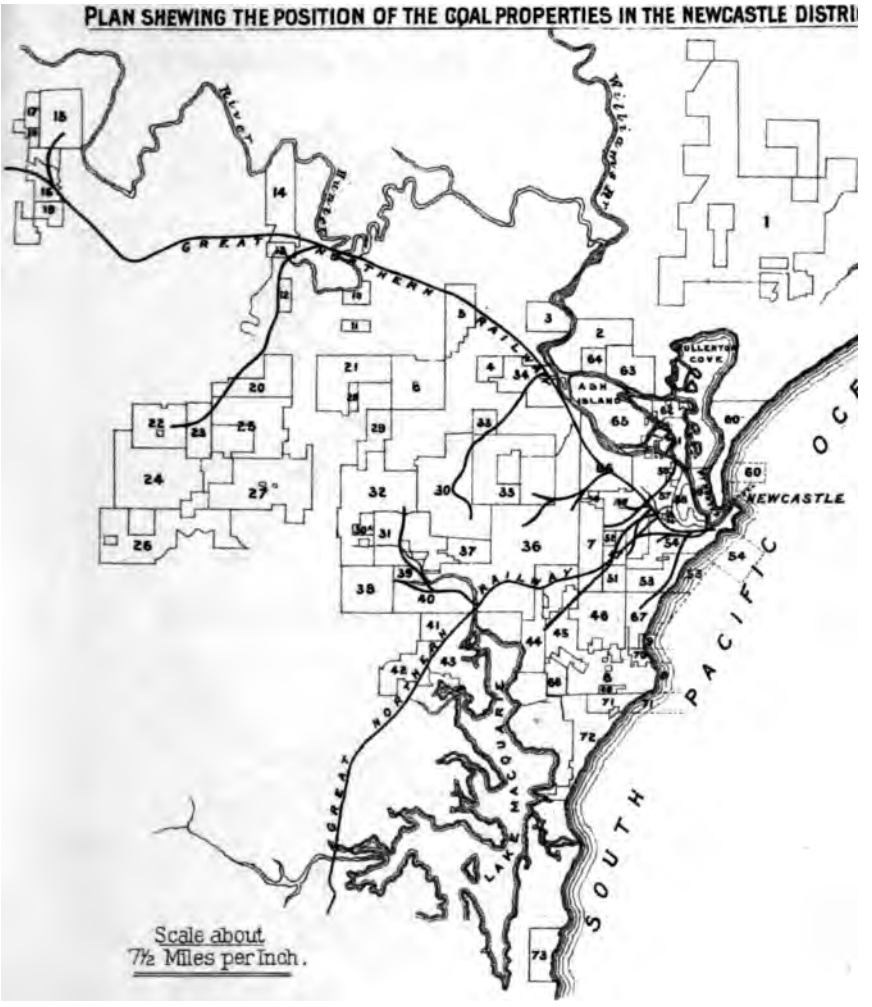


SECTION OF STRATA THROUGH NEW SOUTH WALES COALFIELD.

FIG. 2.



To illustrate Mr. George Blake Walker's "Notes on the Coal-Fields of New South Wales."



REFERENCE.

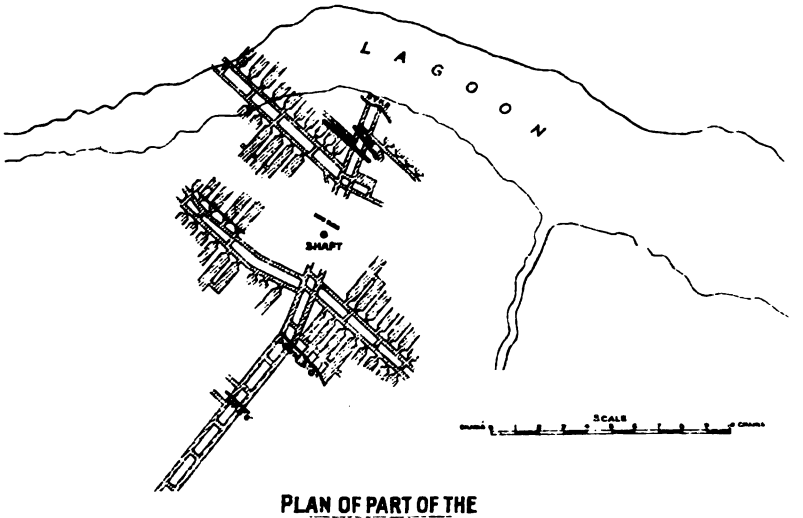
1 Newcastle and Stockton Land and Coal Co.
2 North Stockton Coal Co.
3, 4 W. B. Sharp and others
5 Woodford Coal Co.
6, 7, 8, 9 Scottish Australian Mining Co.
10 Rathluba
11 Bloomfield
12 East Greta Coal Co.
13 Maitland Coal Co.
14 South Greta Coal Co.
15, 16 Greta Coal Co.
17, 18 George Hyde
19 Anvil Creek Coal Co.
20 Heddon-Greta Coal Co.
21 Captain Smith and others
22 Silkstone Coal Co.
23 Hebblewhite
24 Clyde Coal Co.
25 Stanford-Greta Coal Co.
26 John Scholey
27 Richmond Coal Co.
28 Elliott Bros.
29 Jos. Wood and others
30 Minmi and Duckenfield Coal Properties
30a Wallsend Extended Coal Property
31 West Wallsend Coal Co.
32 Monkwearmouth Coal Co.
33 J. & A Brown
34 Fletcher and others
35 Co-operative Coal Co.
36 Newcastle Wallsend Coal Co.
37 Young Wallsend Coal Co.
38 Newcastle New Wallsend Coal Co.
39 Central Wallsend Coal Co.
40 Teralba Coal Co.
41 Sneddon and others
42 Northumberland Coal Co.
43 Great Northern Coal Co.
44 South Wallsend Coal Co.
45 Australian Coal Co.
46, 47, 48 Waratah Coal Co.
49, 50 Waratah Coal Co.
51, 52 Lambton Coal Co.
53 Newcastle Coal Minin
54, 66 A. A. Company
55 Linwood Coal Co.
56 Morgville Coal Co.
57 Ferndale Coal Co.
58 Wickham and Bullock Coal Co.
59 Hetton Coal Co.
60 Stockton Coal Co.
61
62 Moscheto Island
63 Bibby, Blyth, and othe
64 Tomago
65 R. B. Wallace and othe
67 Burwood Coal Co.
68 G. A. Lloyd and others
69, 70 South Burwood Coal C
71 Burwood Extended Co
72 Redhead Coal Mining
73 Wallarah Coal Co.

Andrew Reid, Sons & Co. L

To illustrate Mr. George Blake Walker's "Notes on the Coal-Fields of New South Wales."

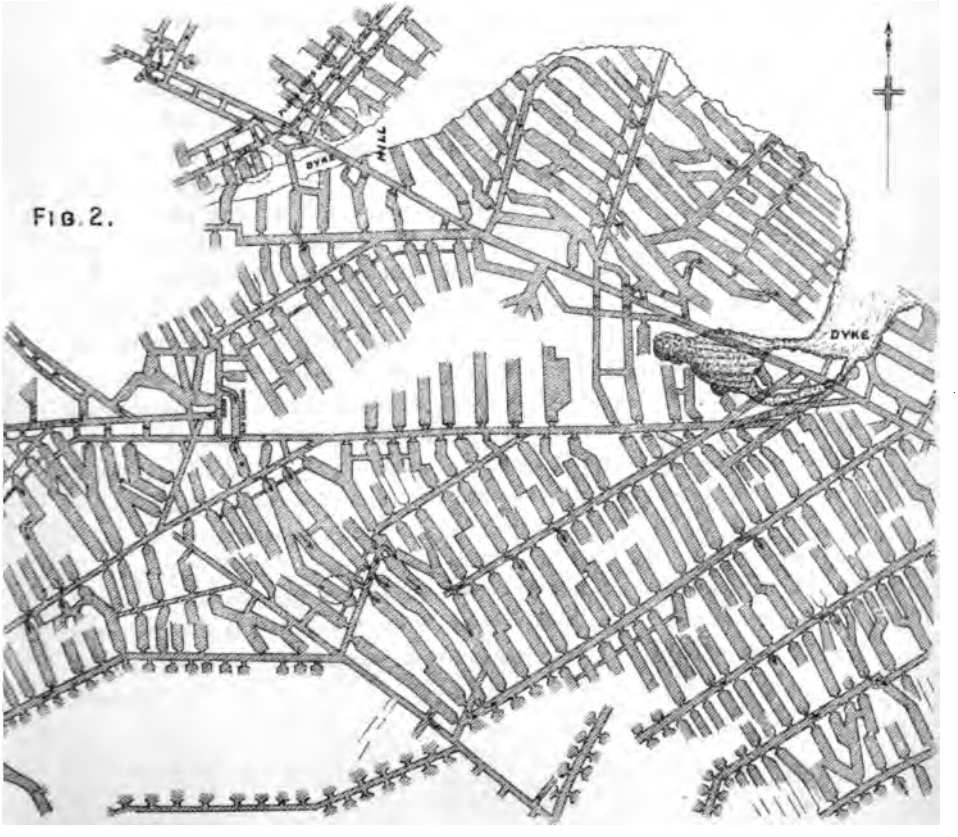
FIG. 1.

PLAN OF WORKINGS OF THE BURWOOD COLLIERY, [NEWCASTLE DISTRICT.]



PLAN OF PART OF THE
WORKINGS OF THE BULLI COLLIERY [ILLAWARRA DISTRICT.]

FIG. 2.



And.W Reid Sons & Co. Lithos, Newcastle

THE COAL-FIELDS OF AUSTRALASIA.

By S. Herbert Cox, F.G.S., Assoc. R.S.M.

A few notes on the vast coal-fields of the Antipodes may not, the writer trusts, prove unacceptable to the members of the Federated Institution, since Australasia, like England, has already found the exploitation of coal a source of considerable profit, and the systematic development of her resources in mineral fuel will doubtless, in the future, prove that there, as here, the possession of coal is perhaps the most stable foundation of a nation's greatness.

Geological.

Mining engineers visiting Australia and New Zealand, with an intimate knowledge of the English coal-fields, find their old landmarks entirely removed, and the Coal-measures occurring under completely different conditions to those which prevail in Europe. The seams, it is true, are equally persistent in either country, and are worked under conditions which assimilate more and more as time goes on; but there are many points of geological interest, regarding those of Australasia, which the writer ventures to think may be worthy of your consideration, and to these he proposes to allude.

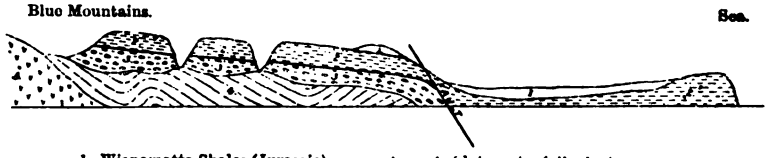
For the purposes of this paper it will be better to divide the deposits into those which contain true coals, and those in which only lignites and brown coals occur, premising that the nature of the coal does not appear to have been dependent upon geological age alone.

The oldest and most important coal deposits are found in New South Wales, where they occupy an easily accessible position along the eastern sea-board, and extend back for some distance into the interior. These deposits occur in three distinct series, each separated from the other by some thousands of feet of unproductive strata, and each consisting of several seams of coal of varying quality.

The fossils, both marine and terrestrial, have shown that these beds are homotaxial in age, with the upper part of the Carboniferous and the lower part of the Permian systems of Europe, and, as a whole, there is no break or unconformity of importance, from the highest members to the base of the coal-bearing group, beyond such as necessarily arise from the oscillations of the land during deposition, but which entirely evade detection.

The deposits, however, as they now exist, owe their position to heavy faulting, which has resulted, in the first instance, in bringing a large coal-bearing area to the level of the sea, and providing natural harbours for shipment; and, in the second, in robbing Australia of a large area of coal which is now submerged below the Pacific Ocean.

The accompanying sketch section, extending from the Blue Mountains to the sea, will serve to illustrate the effects of this faulting.



1. Wianamatta Shales (Jurassic).
2. Hawkesbury Sandstone (Triassic).
3. Coal-measures (Carboniferous).
4. Slates, etc. (Silurian).
5. Granites.

There can be no doubt that the Coal-measures, together with the Hawkesbury or Sydney sandstones which overlie them, originally formed a long plateau which extended much farther to sea than the present eastern boundary of Australia, and that this plateau was traversed by rivers of considerable size, of which the Nepean was a tributary stream, and the Parramatta, perhaps, the principal river, the numerous arms of the Sydney harbour having, at that time, been occupied by rivers draining the plateau. The result of the faulting, which had a downthrow to the east, was to bring the Coal-measures to a point below sea-level in the Sydney harbour, and it was sufficiently great to submerge all those streams that have been mentioned, the sea flowing into which formed the Sydney harbour as it now exists.

Although at Sydney the Coal-measures cannot be seen, they occur both to the north and south of that city, at Newcastle and Illawarra respectively, forming a syncline below the covering Hawkesbury sandstones; and the relations of the under and overlying beds becomes a matter of the greatest interest and importance, to which the writer will refer later on.

The area occupied by the Coal-measures in New South Wales has been estimated by Mr. C. S. Wilkinson, the Government Geologist, at 23,950 square miles, of which an area of 3,328 square miles contains coal at a workable depth, the available tonnage of which he estimates at 14,370,000,000 tons.

Beds of the same age also occur in Queensland, containing true coal, but not under such favourable conditions as those prevailing in New South Wales.

Those in Queensland occur in two different areas known respectively as the Burrum coal-field, which is connected with the port of Maryborough by railway, but in which the coal, while of excellent quality, is of a somewhat tender nature; and the Dawson and Mackenzie field, lying farther back from the coast, which, while containing good and workable seams of coal, has not hitherto received much attention in consequence of its geographical position; it, however, contains vast supplies of mineral fuel which will be worked in the future. The geological horizon of this latter field would appear to be somewhat lower than that of the Burrum.

In Tasmania, again, there are beds of the same age also containing seams of true coal and anthracite, which are worked in a small way, but their quality has never proved as good as that from New South Wales, and they have, consequently, not received very much attention.

With the exception of those places cited, true coals have not yet been found in Australasia in beds of Carboniferous age, but even these, with a surface area of perhaps 6,000 square miles in which workable coal seams occur, represent enormous potentialities for the colonies.

In New Zealand, however, there are deposits of true coal occurring in beds of Cretaceous age—coals, moreover, which may justly lay claim to being almost the best in the world. The seams are thick and very free from bands, while the coal forms a good coke, and, above all, contains so small a proportion—not more than 1½ per cent. of ash on an average—that it would be difficult to mention any other mines where the quality of the coal is superior.

These coal beds are confined entirely to the West Coast of the South Island of New Zealand, of which Greymouth and Westport are the most important harbours, but their exact area is difficult to determine. They are worked from 600 feet below sea-level to an altitude of 2,000 feet above the sea, and are proved, as seams 30 feet thick, as much as 3,500 feet above sea-level. The formation altogether is a most remarkable one, for the sandstones with which the coals are interstratified are frequently so indurated and interlaminated with scales of mica that, in hand specimens, they resemble gneiss far more closely than an unaltered sandstone. The measures themselves, moreover, enter into the structure of the mountains, having, in many cases, been folded and contorted during upheaval, and it is only in comparatively few localities, notably at Greymouth and Westport, on what are known as the Brunner and Buller coal-fields, that they are sufficiently undisturbed to afford a large area over which the coal can be won.

In these places the seams vary in thickness from 6 feet to 40 feet, and are generally solid, clean, compact coals, the principal variation being in the percentage of hydro- and fixed carbon present, those from some localities being better suited for gas, and from others for steam.

To return to Queensland, there are seams of coal worked at Ipswich, which belong to the true coal series, but are inferior in quality to those which have been mentioned, and these occur in beds of the Lower Mesozoic period, most likely of Triassic age. They are worked vigorously at numerous small pits, chiefly for local supply, and notwithstanding their inferior quality have a moderate sale, for the mines being close to Brisbane they are able to compete on favourable terms with sea-borne coal.

These deposits are chiefly of interest on account of their geological age, for they are the only beds of coal in the Lower Mesozoic rocks, of sufficient size to work, which have yet been discovered, notwithstanding the fact that both in New South Wales and New Zealand the beds in question are very largely developed, and in both colonies contain numerous seams from 6 inches to 1 foot in thickness, and of very fair quality. There are also small areas in Victoria where coals have been worked, with but slight success, in beds which are probably of this age; but, up to the present no seams of importance have been found.

There still remain the brown coals and lignites to allude to, which have assumed considerable importance in New Zealand.

It may be mentioned that all coals containing over 10 per cent. of water in their composition are comprised in this class, and that the percentage of water is generally a very fair criterion of their quality.

Some of the brown-coal deposits in New Zealand are undoubtedly of Cretaceous age, equivalent in fact to the bituminous coals of the West Coast, while others are Tertiary, mostly Oligocene and Miocene. It is not the object of this paper to discuss their exact geological position, so they may be passed by with the statement that in New Zealand they are confined to the North Island, and to the eastern side of the main range in the South Island, in both of which areas they are largely worked; and that they occur in Oligocene beds in Australia. The importance of these deposits, like those of Ipswich, depends upon their ability to compete locally with the more valuable sea-borne coal.

Having alluded in a general way to the geological age of the different coal-bearing deposits, it will be evident that there are certain points in connexion with these beds which merit some special attention, and the first of these is the quality of the different seams.

The simplest way to compare these is in a tabular form, and the following carefully prepared table will show their qualities at a glance:—

TABLE OF ANALYSES OF AUSTRALASIAN COALS.

LOCALITY.	Fixed Carbon.	Hydro-carbons	Water.	Ash.	Sulphur.	REMARKS.
Buller Coal-field, N.Z.—						
Wellington Co. (crushed)	76·90	16·20	·80	6·10	Not determined.	Skey.
Ngakawau „	74·68	21·51	2·61	1·20		„
Westport Co.	61·75	34·20	2·53	1·54		„
Plateau	66·12	28·82	4·25	·81		„
„	59·88	32·57	6·66	·89		„
„	66·34	29·91	2·78	·97		„
Mokihinui	55·43	38·38	4·67	1·52		„
Greymouth Coal-field, N.Z.						
Greymouth Coal Co. ...	53·03	41·95	·99	3·98		„
Brunner „ ...	53·50	41·28	1·41	3·81		„
Coal Pit Heath „ ...	59·38	35·48	1·05	4·09		„
Greta Coal-field, N.S.W.—						
Greta mine	54·41	39·21	2·25	1·41		Liversidge.
Newcastle Coal-field, N.S.W.						
Aust. Agr. Co.	57·52	33·60	2·20	5·35	1·33	Liversidge.
Minmi	56·49	33·87	2·59	5·61	1·44	„
Glebe	59·16	33·36	2·14	4·76	·58	„
New Lambton	59·56	30·62	2·61	6·72	·49	„
Wallsend	57·22	34·17	2·75	4·64	1·22	„
Waratah	55·82	36·70	2·21	4·15	1·12	„

TABLE OF ANALYSES OF AUSTRALASIAN COALS.—*Continued.*

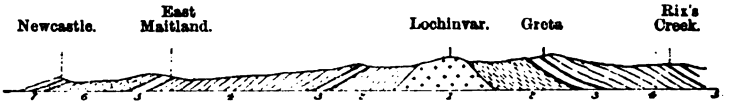
LOCALITY.	Fixed Carbon.	Hydro-carbons	Water.	Ash.	Sulphur.	REMARKS.
Bay of Islands, N.Z.—						
Kawa Kawa mine ...	57·29	36·00	4·60	2·20	Not determined.	Skey.
Lake Macquarrie, N.S.W.						
Lake Macquarrie ...	49·48	43·36	1·85	4·96	·35	Liversidge.
" "	54·66	31·93	3·65	8·82	·94	"
" "	53·88	31·95	2·31	11·12	·74	"
Redhead	57·04	33·48	2·09	6·84	·55	"
Illawarra Coal-field, N.S.W.						
Bulli	61·61	23·65	1·03	13·17	·54	"
"	65·68	21·65	·65	11·28	·74	"
Coal Cliff...	69·84	18·22	·86	10·80	·28	"
Mount Kembla	67·18	19·74	1·50	10·72	·86	"
Mount Pleasant	68·08	22·04	·70	8·76	·42	"
Mountain Coal-field, N.S.W.						
Lithgow Valley Coal Co.	52·34	34·18	1·95	10·12	1·41	"
" " "	58·80	28·48	2·24	9·68	·80	"
Eskbank Coal Co. ...	57·88	28·78	2·70	9·88	·76	"
" " ...	49·97	33·55	2·00	12·91	1·57	"
Vale of Clwydd	52·36	35·02	2·15	9·72	·75	"
" "	53·38	33·35	2·10	9·80	1·37	"
Queensland Coal-fields—						
Thomas mine, Bundambe	59·20	29·80		11·00	Not determined.	A. C. Gregory.
Jones mine, Ipswich ...	61·50	28·90		9·60		"
Waterstown mine " ...	62·00	25·20		12·80		"
Tivoli mine " ...	66·40	26·70		6·90		"
Walloon mine, Moreton...	42·00	41·00		17·00		"
Burrum mine, Marybro'	64·00	31·50		4·50		"
Southern District, N.S.W.						
Berrima	62·28	26·61	1·26	9·40	·45	Dixon (extra good sample).
Wingello	58·60	24·87	1·96	14·04	·53	Dixon.
Tasmanian Coal-fields—						
Sandfly ranges (18in. seam)	62·20	23·30	5·00	8·70	·80	D. Lewald.
" (28in. seam)	63·50	15·70	5·30	14·70	·80	"
" (4 ft. seam)	67·00	12·70	5·40	14·30	·60	"
Gardeners Bay	63·50	15·70	2·90	17·90	Not determined.	"
Enterprise mine	53·10	13·90	3·70	29·30		"
Adventure Bay	69·90	14·20	3·00	12·90		"
Black Diamond	58·40	16·40	4·10	21·10		"
Jerusalem.	56·80	12·50	2·80	27·90		"
Green Port, Port Cygnet	64·80	19·90	1·20	14·10		"
Kaitangata Coal-field, N.Z.						
Kaitangata Co.	46·84	40·52	9·20	3·24	Not determined.	Skey.
" "	44·18	38·22	15·41	2·19		"
Shag Point Coal-field, N.Z.						
Shag Point mine... ...	43·15	33·70	14·40	1·00		"

TABLE OF ANALYSES OF AUSTRALASIAN COALS.—*Continued.*

LOCALITY.	Fixed Carbon.	Hydro-carbons	Water.	Ash.	Sul-phur.	REMARKS.
Whangarei Coal-field, N.Z.						
Whau Whau	47·91	40·70	8·19	3·20	Not determined.	Skey.
Kamo mine	50·01	37·69	9·61	2·69		,,
,, ...	50·58	36·52	9·25	3·65		,,
Malvern Hills Coal-field N.Z.—						
Springfield	59·90	26·60	9·40	4·10		,,
,, ...	47·80	27·80	18·20	6·20		,,
Homebush	41·80	29·60	26·20	2·40		,,
Wallsend	36·80	29·10	26·80	7·30		,,
Canterbury	46·02	26·99	21·66	5·33		,,
Stevenson...	53·30	32·95	9·98	2·75		,,
Waikato Coal-field, N.Z.—						
Kupa Kupa mine ...	47·45	29·11	15·00	2·45		,,
Taupiri	44·40	35·30	18·90	1·40		,,
Green Island Coal-field, N.Z.—						
Fern Hill Co.	35·70	39·80	23·10	1·40		,,
Green Island Co.... ...	40·30	37·78	17·95	3·97		,,
Walton Park	41·23	36·97	18·07	3·49		,,
Saddle Hill	42·39	41·04	14·22	2·29		,,

It will be seen that the New Zealand West Coast coals stand alone as regards their quality, which is first-class; but, in studying the analyses of those which come from New South Wales, the quality will be seen to vary a great deal, and it is to these in particular that the writer wishes to call your attention.

The section of the New South Wales Coal-measures is approximately as follows in the Newcastle district, which is the only locality where the relations of the different members of the Coal-measures can be studied successfully :—



SECTION SHOWING RELATIONS OF NEW SOUTH WALES COAL-MEASURES.

1. Diorite.
2. Lower marine series.
3. Lower Coal-measures.
4. Upper marine series.
5. Middle Coal-measures.
6. Unproductive strata.
7. Upper Coal-measures.

The lowest are those of Greta, which have been broken, at Lochinvar, by a porphyritic diorite dyke, against which the measures are tilted at high angles, dipping away on either side at 60 degrees, and even steeper; but, at a comparatively short distance off, they have assumed an easier dip, as at the Greta mine, and the beds lap round the southern end of the dyke in an almost unaltered position. The outcrop of these measures has been traced through a point near Raymond Terrace

to the shores of the Karua River, a tributary of Port Stephens, but the coal has only been worked at Greta and Anvil Creek, and opened up in a few other places, such as Richmond Vale, etc. In quality it is very good, and the analyses are uniform. There is a good deal of pyrites in parts of the seam, but in other respects it is of excellent quality.

There are certain other beds of coal near Jervis Bay, at the southern end of the coal-bearing area, which appear to correspond in quality with that from Greta, and, from their position in the section, it is most likely these seams occupy the same horizon.

The next overlying series, which is separated from that of Greta by a thickness of fully 5,000 feet of marine beds, is known as the "Middle Coal-measures." The section of coal-bearing beds from Newcastle to Greta is as follows, being compiled from the reports of the Geological Survey of New South Wales :—

TABULAR STATEMENT OF COAL-MEASURES IN NEWCASTLE DISTRICT, NEW SOUTH WALES.

1. Upper Coal-measures 500 feet thick	Productive measures of fresh-water or estuarine origin consisting of sandstones and shales with numerous seams of coal.
2. Non-productive measures 2,000 feet thick	Sandstones, shales, mudstones, and conglomerates.
3. Middle Coal-measures 700 feet thick	Productive Coal-measures of fresh water or estuarine origin containing a thickness of about 36 feet of coal, out of which 22 feet has been worked from time to time.
4. Upper marine series. Thickness, probably at least 5,000 feet. Not known to contain coal	100 feet (about) *Sanguinolites beds*, 300 feet (about) finely laminated cherty carbonaceous shales and mudstones—1,700 feet (about) strata, chiefly clayey, exact characters at Maitland not known, owing to their being hidden under alluvial deposits —2,900 feet (about) marine conglomerates, sandstones, and sandy shales with large "erratics."
5. Lower Coal-measures. Thickness 300 feet	300 feet lower Coal-measures, in the upper half of which occur five seams of coal, having an average thickness of 17 feet. Three seams have been worked and two are now being worked.
6. Lower marine series ...	1,000 feet (at least) lower marine series, sandstones, shales, and conglomerates. No coal.

The Maitland beds appear to belong to the same horizon as the principal Illawarra coals, which occur south of Sydney, extending along the coast from Coal Cliff to Mount Kembla, and, passing inland, under high precipitous cliffs which guard the coast, are not met with again, save in the mines, until the main southern railway line is reached, where, at Berrima, Wingello, and other points, coal occurs, which has

in most places been very much shattered and broken by faults and dykes, although at Wingello an area of undisturbed coal occurs which is very similar in composition to that found in the Illawarra mines. The measures extend from here, through the mountains, to Lithgow and Hartley Vale, where the coal is thick and unbroken, but in quality more nearly approaches to that of East Maitland than to that of Illawarra. It is a remarkable fact that while the Wingello coal is almost identical with that of Lithgow in physical characters, its analysis is more nearly allied to that at Illawarra, thus apparently forming a link between the two.

It is, moreover, worthy of mention that the well-known Kerosene shale of Joadja Creek is associated with these measures, and that in the Lithgow district the same mineral occupies that horizon at Hartley Vale, so that many points exist which serve to correlate the beds, irrespective of geological evidence pure and simple. It may thus be taken that the middle Coal-measures have been worked over a very wide area, and vary in quality between that of Illawarra and that of East Maitland.

Overlying these in the Newcastle district come the upper or Newcastle Coal-measures, separated again from those of East Maitland by about 2,000 feet of unproductive rock, and in this series, which is about 500 feet thick at Newcastle, but much thicker at Lake Macquarrie, a great number of seams have been proved. The best known seam, and that which has hitherto yielded almost the entire supply of coal from Newcastle, is that known as the Borehole seam, worked by the Australian Agricultural Co., Wallsend, Stockton, and all the principal mines. It is the lowest workable seam of the series, but above it there are many which may be worked.

At Lake Macquarrie the Wallarah Co. are now working one of these upper seams, and in the future many of them will no doubt receive attention, although in consequence of their percentage of ash being somewhat higher, there is no doubt they are not of as good quality as that of the Borehole seam.

These upper Newcastle Coal-measures dip at low angles to the south and west until they pass below the Hawkesbury sandstones, and the passage, from one series to the other, is so gradual that it is hard to say where one ends and the other begins.

The same remarks would apply to the Illawarra beds, to the south of Sydney, which have a gentle northerly dip, and are overlain by the Hawkesbury sandstones, which also rest upon the Lithgow and Hartley Vale measures.

It will be evident, therefore, that since the Hawkesbury sandstone rests, at different places, upon different members of the Coal-measures, there must be an unconformity between them, and this has a most important bearing upon the extent of the Newcastle Coal-measures, and also upon a very vexed question, viz., the existence of coal, below the Sydney harbour, at workable depths.

It may be said that exploratory workings carried on on the western side of the coast coal-field, where it is cut off by the Penrith fault from the western or mountain coals, have not, as yet, been successful; but several boreholes have been sunk near the sea and in the vicinity of Sydney, affording some information regarding the extension of the Coal-measures. The coals dip below sea-level to the north of Sydney,

near the Monmorah Lake, and have been proved by boreholes at Wyong to continue as far as that point, but beyond this they have not been tested.

In the south the Illawarra seams disappear below sea-level at Coal Cliff, and have been proved as far north as the borehole on the Holt-Sutherland Estate. The boreholes around Sydney have been as follows :—

During 1878 a borehole was put down at Newington, by Mr. Coghlan, to a depth of 1,312 feet, where the bore became choked. It is stated to have passed through the Hawkesbury sandstones and to have pierced the Coal-measures with *Glossopteris*, but no coal was struck. A borehole was commenced at Moore Park during the same year, and in 1879 attained a depth of 1,850 feet without striking coal; and in the same year the first borehole on the Holt-Sutherland estate, at Botany, reached a depth of 2,170 feet, also without satisfactory results. Besides these, three boreholes were sunk at Gladesville in 1883, through sandstones and shales, the deepest being only 442 feet; and one at Breakfast Creek, Penrith, in 1884, passed through 737 feet of sandstones and shales without reaching the Coal-measures.

To the north of Sydney, between the Hawkesbury river and Newcastle in 1883, the Dora Creek bore reached a depth of 475 feet 10 inches, proving coal at 372 feet 6½ inches from the surface; and the Wyong bore in the same year attained a depth of 901 feet 1 inch, striking coal at the bottom; while to the south of Sydney, at Stanwell Park, north of Coal Cliff, there were two boreholes, sunk to a depth of 438 feet and 244 feet respectively. In these coal was struck at the following depths:—

No. 1.				No. 2.	
Ft.	In.			Ft.	In.
219	1½	...	...	192	2½
231	0½	...	...	202	1½
259	2½	...	...	238	0½
298	9½	...	...	—	
349	0½	...	...	—	
405	4	...	...	—	

Coal has since been struck on the Holt-Sutherland Estate, and in this connexion it will be better to quote from the report of Mr. C. S. Wilkinson, F.G.S., "Mineral Products of New South Wales, 1887," p. 69.

"On the Holt-Sutherland Estate, at George River, near Sydney, a borehole has been put down by means of the diamond drill to a depth of 2,170 feet, passing for the first 1,000 feet through Hawkesbury sandstones and then into the Coal-measures without proving coal. At a depth of 1,493 feet some ostracod shells of the genus *Estheria* were found in the cores (described by Dr. Jas. Cox, Linn. Soc., N.S. Wales. Vol. V., part III., 1881).

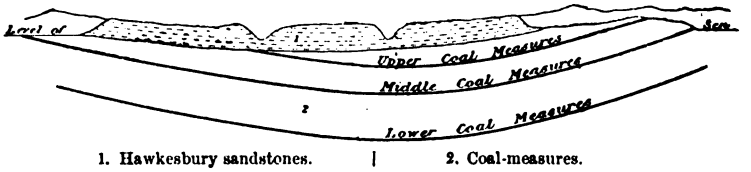
"In the core recently taken from a depth of 917 feet in the diamond drill bore near Mount Westmacott, the *Estheria* has also been found. In this bore the coal seam, 4 feet 8 inches thick, was pierced at 1,518 feet from the surface, or 1,211 feet below the Hawkesbury sandstones; and at a depth of 1,585 feet another seam of coal, 6 feet thick, was passed through.

"Another diamond drill bore was, in January, 1887, completed under the direction of Mr. W. H. Slee, Superintendent of Drills, to a depth of 2,307 feet, at Holt-Sutherland, 16½ miles from Sydney. This is the deepest bore in Australia. To a depth of 500 feet the bore is 3½ inches diameter, and below that depth it is 3 inches. The strata passed through consists of :—

	Ft.	In.
Hawkesbury sandstones	653	6
Shales, sandstones, and conglomerates (the upper 314 feet consisting chiefly of chocolate-coloured ferruginous shales)	1,573	3
Upper seam of coal	4	2
Shales, sandstones, and conglomerates	65	0
Lower seam of coal	5	3
Black shaly sandstone	5	11
Total	2,307	1

These seams of coal are evidently the continuation of the Coal Cliff or Bulli Seams and the same that were pierced in the bores at Mount Westmacott and Heathcote. In this Holt-Sutherland bore, at a depth of from 1,729 to 1,800 feet, Mr. T. W. E David, Geological Surveyor, discovered a bed of shale 70 feet thick, containing numerous crystalline grains of native copper which, on assay, yielded a small percentage of gold and silver. The same bed of cupriferous shale was met with in the Mount Westmacott bore."

It will be evident from the foregoing that the Holt-Sutherland bore which struck coal at 2,226 feet 9 inches from the surface could hardly be upon the Newcastle seams as, if that were the case, some of the other boreholes, as for instance that at Moore Park should have met with them at a less depth, and the only inference that can be drawn is the very self-evident one that the unconformity between the Hawkesbury sandstones and underlying Coal-measures is such as is represented in the following diagrammatic section :—

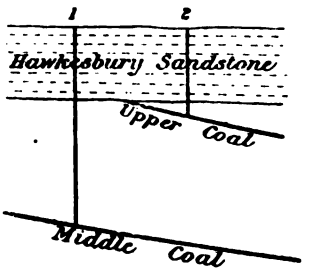


1. Hawkesbury sandstones. | 2. Coal-measures.

from which it will be seen that while the Coal-measures necessarily underlie most, if not all, of the Sydney area, it is quite impossible on the surface to form any conclusion as to the line of outcrop of the upper Coal-measures against the lower margin of the Hawkesbury sandstones, and, consequently, until several deep boreholes have been executed it will be the merest chance should coal be struck at a reasonable depth.

The fact that the upper and middle coal-bearing members of the Carboniferous series are separated, one from the other, by about 2,000 feet of unproductive strata

will at once show that, so far as the knowledge of their position can guide us at present, it is quite probable that a borehole may be sunk a few feet beyond the edge of the upper basin, and thus miss the seams which ought to be struck at a reasonable depth, while, if this occurred, it would be necessary to sink 2,000 feet further before reaching the middle coal-bearing series. This can perhaps be better illustrated by a section than by words :—



1. Borehole missing coal at reasonable depth.
2. Borehole striking coal at reasonable depth.

It will be apparent that, with this uncertainty prevailing, it will be a somewhat speculative undertaking in the present state of our knowledge to bore for coal around Sydney, for, although it will undoubtedly be found eventually, much work may be done before the efforts of investors are crowned with success. The immense advantages which will accrue to the discoverers of coal in the neighbourhood of Sydney over those mine owners who have either sea or land carriage to deal with will, however, no doubt lead to this prospecting being done, and the liberal-minded Government of New South Wales is always ready to assist enterprise of this sort when an advantage to the community at large can reasonably be expected to be gained.

Bearing in mind the varying quality of the coal in the different localities cited, one would think at the first glance that only those mines in which the coal was of good quality could be worked, but in Australasia, more perhaps even than here, there are many other considerations which bear upon the success or failure of a colliery. Perhaps the only way in which one can bring these points under the notice of the Institute is by dealing, however briefly, with the different coal-fields, and alluding to the advantages and disadvantages of each. In doing this it will probably be best to take the different fields in the order of quality of coal, as this will show how some of even the worst seams are worked to advantage.

Buller Coal-field, New Zealand.

The coal seams in this field vary from 4 to 54 feet in thickness, and exist under somewhat remarkable conditions. From the mouth of the Buller River some flat country extends north along the coast for a distance of eighteen miles, and through this the New Zealand Government have constructed a railway.

From the edge of the flat country the mountains rise abruptly to an average altitude of about 1,800 feet, at which level a plateau exists on which there are three peaks, Mounts Frederick, William, and Rochfort, each attaining a height of about 3,500 feet.

The plateau is intersected by numerous steep ravines, and two deep gorges, in which the Waimangaroa and Ngakawau rivers flow, cut through the rocks, nearly to

sea-level, exposing splendid natural sections. There are three small, faulted coal areas at the foot of these ranges in which the coal is generally tilted to an angle of 45 degrees, and even more, and has been so much crushed by the slips or faulting that, while preserving the same chemical composition as that on the plateau, it is so fragile as to be quite useless for all purposes except coking, for which it is excellent.

On the plateau, however, where it has remained undisturbed, the coal is hard and compact, and of such excellent quality that it has induced a very powerful company, the Westport Coal Co., to undertake the work of opening it up. This has been effected by the formation of a branch line of railway, about one mile in length, up the Waimangaroa Gorge, from the terminus of which a self-acting incline has been constructed up a steep spur to a level of 1,800 feet. This tramway is made in two lifts, the upper, in which the steepest gradient is 1 in 1, being controlled by a powerful band brake, while the lower, on which the gradients are far more easy, is worked by a hydraulic brake. The gauge of the rails is 3 feet 6 inches, and the Government railway trucks, carrying 6 tons of coal, are taken up and down.

The screens are fixed at the head of the incline where the trucks are loaded, and at the commencement the mine haulage was done by an endless chain which has since, however, given place to an endless rope, working partly along open cuttings and partly in the mine. The workings here are all on the pillar and stall system, and the coal is, naturally, worked level free.

Another mine commenced operations on the other side of the Waimangaroa Gorge, an endless rope system of haulage being adopted for the incline. This never worked satisfactorily, besides which the mine was opened on some of the slip coal, instead of going to the main undisturbed area, and operations are now stopped.

An English-owned mine has been started lately at the northern end of the area, near the Ngakawau River, but the writer is not acquainted with any of the details of their workings, and north of the Ngakawau River the Mokihinui Mine has worked for some years.

The greatest difficulty experienced on this field has been due to Westport only possessing a bar harbour, on which the depth of water varied very much from time to time. The Government has, however, done much to improve this by carrying training walls out to sea, and providing wharves, coal staiths, etc., so that now coal can be shipped at all times in vessels carrying a large tonnage. The expenses of the incline have also formed a heavy charge on the coal, so that were it not for its excellent quality it would never have paid to work. The principal company is now reported to be working successfully, and there is every reason to believe that others will also prove successful.

THE BRUNNER COAL-FIELD, NEW ZEALAND.

In this district the Brunner Mine has supplied the principal output, and, being very favourably situated, has enjoyed advantages that are seldom met with. The New Zealand Government constructed a railway from the port of Greymouth up the

southern side of the Grey River to Brunnertown, and crossed the river at that point on a suspension bridge.

The main level of the Brunner Mine was driven into the side of the hill from a point close to this terminus, and so all the coal received very cheap transport; and for many years this mine turned out the largest yield in New Zealand, which has, however, of late years been surpassed by the Westport Coal Co.

Besides this mine, the Coal Pit Heath and Greymouth-Wallsend have both been worked by shafts, the former having contributed a considerable quantity of coal to the general output, while the latter, after expending a large sum of money in shaft sinking and machinery, has, for some reason or other, been shut down for most of the time.

The coal is as much as 18 feet thick in places, and has been worked on a pillar and stall system with tail-rope haulage, the whole thickness of the coal being taken in the bords, and the pillars robbed as much as the safety of the miners would permit. There has been a little gas found in these mines, that of Greymouth-Wallsend giving off a considerable quantity.

Greymouth, like Westport, has had a bar harbour to contend with, and a large sum of money has been expended by the Government in improving it, with very satisfactory results, so that at the present time the coal receives rapid transport. There is a large area of coal-bearing land in the district in addition to that held by the mines mentioned, which has not yet been worked, but in which the quality of the coal is very good.

The Newcastle and Greta Coal-fields, New South Wales.

This is by far the most important field yet opened up as regards extent, number, and size of the mines, good average quality of the coal, and facilities for shipment. The railage rate for the mines around Newcastle is only 10d. per ton, including dock dues, and the mines are consequently working on a very level basis. By means of co-operation on the part of the colliery owners the vend price is fixed, being at present 11s. 6d. per ton for round coal at Newcastle, and all the coal is loaded into vessels by the Government hydraulic cranes, which are placed along the wharves.

The greatest difficulty which has been experienced here is due to the powerful miners' union, which has decided that no coal shall be hewn in the district under 4s. 2d. per ton for the standard seam, with a sliding scale for seams above and below the standard measurement.

As, however, all the principal collieries are working the same seam of coal, and are subject to the same conditions, the relations of the different mines remains much the same.

This does not apply, however, to the mines of East Maitland and Greta, in which the railway carriage is higher, those of East Maitland being subject to a rate of from 1s. 3d. to 1s. 7d. per ton, and Greta, by special arrangement, to 1s. 10d. per ton; the

result of which is, practically, to shut out the East Maitland mines from the Newcastle market, and limit their sales to the immediate vicinity, and Morpeth where some steamers coal.

Greta, however, has managed to compete with Newcastle on even grounds, and notwithstanding the cost of carriage has had a large output, this being partly accounted for by the greater thickness of the seam. The principal market has been in San Francisco.

There have, of late years, been many new collieries opened in this district which have met with varying success, but they have hardly perhaps had a sufficiently long existence to enable one to speak with certainty regarding their future.

The mines, as a whole, are worked on a pillar and stall system, longwall having only been introduced in a few instances. The depth of sinking is seldom over 400 feet, and the haulage is mostly on the tail-rope system, although the endless rope is employed in a few mines. The pillars are generally left narrow, and robbed as much as possible, but no provisions are made for drawing them completely, a condition which has pretty generally prevailed in working shallow mines.

The district has suffered severely of late years from strikes which have paralysed the industry, but the following statement of yields for a period of ten years, extending from 1880 to 1889, will afford some idea of the magnitude of the works :—

	Tons.
1880	673,393
1881	899,369
1882	1,080,446
1883	1,359,505
1884	1,505,395
1885	1,552,136
1886	1,544,694
1887	1,658,386
1888	1,580,337
1889	2,091,557

The shipping facilities are exceptionally good, many vessels of 1,000 and 1,500 tons being loaded, and with the great extent of wharfage accommodation—over two miles of frontage—and enough cranes to load 17,000 tons of coal a day, a very large output can be maintained, governed only in fact by the demand, as there are several mines now opened out which can turn out over 1,000 tons of coal a day.

The Kawa Kawa Coal-field, New Zealand.

This is represented by the Kawa Kawa Mine, which has been one of the largest producers in New Zealand for a number of years, since, in addition to the good quality of the coal, it has, by its situation, and the good harbour at the Bay of Islands, had exceptional opportunities of securing the ocean-going trade in the North of New Zealand.

Several of the Union S.S. Company's vessels coal here, and the steamers trading to San Francisco from New Zealand have also made the Bay of Islands a coaling

station. The seam has varied from 6 feet to 10 feet in thickness, and for many years the coal was brought by "lighters" from the mine to the coaling station. The seam was worked by an engine plane, and on a post and stall system, the pillars being left strong, and subsequently drawn. Where the coal thinned, a longwall system of working was introduced, and the mine generally was worked on good and economical lines.

In working to the dip, a downthrow fault was encountered, beyond which the seam split into two thinner seams, the quality of which was not so good as that previously worked, and for some years the mine had much difficulty in supplying the demand upon it. One great advantage enjoyed by this mine has been, that the proportion of round coal obtained was very considerable, so much indeed that none of the coal was screened, but everything, as it was brought out of the mine, was supplied to the steamers.

The Government constructed a line of railway from the mine to the port which was only completed about the time the supply of coal began to fall short, and thus for some time but little traffic was provided for it.

The Lake Macquarrie Coal-field, New South Wales.

There is only one mine, the Wallarah, working here at present, and this, notwithstanding the fact that the coal is not of as good quality as that at Newcastle, appears to be making steady progress, the output having been lately at the rate of about 4,500 tons per month. They have one great advantage here over Newcastle, in that they are situated on the coast, and, having run out a jetty in a protected position, are enabled to load direct from their skips without tipping into trucks; and they also avoid railway carriage.

There is a great extent of coal-bearing strata in this district which is held for coal mining purposes, and it will no doubt, in the future, be a scene of busy enterprise.

The Illawarra Coal-field, New South Wales.

This field has similar advantages to that of Lake Macquarrie, in that the mines being situated along the coast line, and above sea-level, all the coal is wrought level free, and is brought by short, private railway lines on to private wharves, built along the margin of the well-protected bay, at which shipping can go on during most of the year. They have, moreover, another and still greater advantage, in that, while a miners' union exists, the hewing rate has not been fixed, and in those mines where the seam of coal is of good thickness, the price paid for hewing is at times as low as 2s. 4d. per ton. There has, however, been a good deal of competition amongst the owners, and although the coal is excellent for steaming purposes the amount of ash is high, and the sale price has consequently been kept a good deal lower than that at the Newcastle mines. Notwithstanding all this several of the mines have been very productive, and a judicious combination would probably enhance the yields.

The Bulli Mine, in this field, has been the only one in the colony where any serious explosion from fire-damp has occurred.

The mines are chiefly worked on a pillar and stall system, with tail-rope haulage underground.

THE MOUNTAIN COAL-FIELD, NEW SOUTH WALES.

The coal in this district is again of an inferior quality to that of Newcastle. It, however, commands a ready sale in the district, is used on the railway, and even a considerable quantity reaches Sydney, where, from its qualities as a household coal, it commands a good sale, while for the interior of the colony, and extending almost to the Victorian border, it enjoys almost a monopoly, in consequence of the position of the mines. Perhaps the greatest difficulty that has prevailed here has been the unreasonable competition amongst the different mines—the Government contract for the supply of coal to the railway having several times been taken as low as 4s. 6d. per ton at the pit, a price which it is evident can leave little, if any, margin of profit.

THE QUEENSLAND COAL-FIELDS.

In the Burrum Coal-field there are five seams of coal, four of which have been worked and which vary from 2½ feet to 5 feet in thickness, while at Ipswich the seams worked are from 3 feet 4 inches to 6 feet thick. Although there are several mines at these two localities, none of them are worked on a very extensive scale, and the largest output from the Ipswich district in any one year to 1887 was 189,608 tons from all the mines.

The proportion of ash in the Ipswich mines somewhat limits the sale of coal; in Brisbane, and the country around Ipswich, it is used, but there is not much export trade done; and the Burrum mines all produce coal of such tender quality that, while in other respects the coal is good, this quality militates seriously against its use on steamers and its export.

There is some excellent coal on the Mackenzie and Dawson fields, as already mentioned, which is not yet worked; and it is worthy of mention that Mr. R. L. Jack, F.G.S., the Government Geologist of Queensland, records the occurrence of a thick seam of anthracite of the following exceptionally good composition :—

Fixed carbon	84·74
Hydro-carbons...	8·71
Water	2·99
Ash	3·56
	100·00

THE TASMANIAN COAL-FIELDS.

These have hitherto had but a very limited production, the total output in 1888 only reaching 41,577 tons, since, although the coal has to be classed as a true coal, the very high proportion of ash in its composition reduces its value very much and limits its consumption to local requirements, although it is being used to some extent in the locomotives.

THE KAITANGATA COAL-FIELD, NEW ZEALAND.

This field is represented by one mine, owned in Dunedin, and has been worked in a very systematic manner, and often under considerable difficulties. The earlier workings were level free, on a seam which was as much as 30 feet thick at times. The company constructed a private railway six miles in length, and from there to Dunedin the railage by the Government line is about 50 miles.

The area of level free coal, however, was exhausted some years ago, and the seam dipping rapidly at an angle of 45 degrees it was worked by an engine plane on the floor of the coal, and opened with bords and pillars on either side of it. This operation proceeded very well, even with this thick seam, until the work of drawing the pillars was commenced, when the mine fired, had to be closed down, and fresh shafts sunk to the dip, where the coal has assumed a more normal dip, and is still being worked. This coal contains about 10 per cent. of water, and 3 per cent. of ash, is very free burning, and as a household coal, and also for use on the locomotives, has a very ready sale.

The most serious explosion of gas in New Zealand occurred in the old workings of this mine, the gas having accumulated in the large chambers excavated in the thick seam, and a little gas has frequently been detected in the later workings. Notwithstanding all the difficulties the mine has had to contend with, it has, however, been a very successful one.

THE SHAG POINT COAL-FIELD, NEW ZEALAND.

This is also represented by one mine only, which has had a very chequered career. Like Kaitangata the earlier workings were level free, and, like it again, the workings fired, and had to be built in at considerable expense. The coal was then traced below the sea, where it was worked on a pillar and stall system, but the pillars were left very weak in many places, falls of the roof took place, and eventually the inspector had to close the workings and frame rules, which must be followed in any subsequent work in order to secure the safety of the miners. It is some years since the writer visited this mine, and he is not aware how it is going on at present. The coal was good of its class, somewhat approaching Kaitangata in quality, but not quite so good.

THE WHANGAREI COAL-FIELD, NEW ZEALAND.

This field has been worked on a small scale for a number of years, the Whau Whau and Kamo being the only mines, but it is only lately, owing to some extent to the falling off in the yield from Kawa Kawa, that they have assumed much importance. The seams are from 6 feet to 10 feet thick, and the quality fair, as will be seen by the analyses in the table, but the shipping facilities are by no means good, and the consumption has been local, with a small trade in Auckland. Of late years, however, Kamo has secured some of the ocean-going steamer trade, and the output has considerably increased. The Whau Whau Mine has been worked all along

by a small party of working miners, who have never been in a position to secure a large output; and Kamo was for many years very carelessly worked in a hand-to-mouth manner.

The Malvern Hills Coal-field, New Zealand.

There are several mines, none of which ever assumed any very large dimensions. Some of them, however, had a fair output for some time, of which the Homebush Colliery worked level free, and the Springfield Colliery worked level free at first, and afterwards by shafts contributed the greatest quantity of coal.

The consumption of this coal, however, was entirely upon the short railway from Christchurch to the mines, and in Christchurch itself, where it had to compete with the Newcastle and West Coast coals, which were brought by sea, and although the mines were worked to a profit for some time they were never of a very permanent nature.

The Waikato Coal-field, New Zealand.

This field has consisted of three mines, the Kupa Kupa, Miranda, and Taupiri, the two former of which have only been worked on a very small scale, as owing to their less favourable position than that occupied by the Taupiri Colliery, they had difficulties in competing with it except by incurring a somewhat heavy expense. The seams of coal are very thick, that of the Miranda being 54 feet thick, Taupiri up to 40 feet, and Kupa Kupa, at places, 20 feet thick, but the quality is very inferior, as will be seen by the analyses.

The Waikato Railway, however, passes close to the Taupiri Mine, as also do the steamers which ply on the Waikato River, so that a good market is provided for the coal. The workings have been on a pillar and stall system, the bords being taken low at first, and then the tops dropped, and a large proportion of the pillars have been drawn, although, the roof being nothing but clay, and the height of the seam precluding the possibility of timbering, this has been a somewhat risky undertaking. The Taupiri Mine has, however, been one of the most successful in New Zealand, the manager having informed the writer that, for many years, it paid 40 per cent. per annum on the capital.

The Green Island Coal-field, New Zealand.

In this field was worked what is probably the worst coal in the colonies, and, still, the six mines located there were all of a successful nature. The seams were of good thickness and free from bands, the sinking was shallow, the railway passed right through the centre of the field, and Dunedin was only a few miles away, so that the coal was supplied at a very cheap rate, and managed to compete very well with that brought from elsewhere. The exigencies of cheap work, however, brought its own punishment, and, as all the slack coal was left in the mines, the slack heaps became ignited by spontaneous combustion, and, one after the other, the mines fired, and had to be closed down and fresh places opened up. This has resulted in the closing of some of the pits, and the more provident have drawn their slack, which,

at the Walton Park Mine, has been used for burning bricks in one of the continuous kilns stoked with slack through holes in the top. Green Island, notwithstanding, is an excellent illustration of how a very inferior coal can be made to pay when other conditions are favourable.

CONCLUSIONS.

The conclusions which must be drawn from the brief summary of facts that the writer has recapitulated are—that both Australia and New Zealand are fortunate in the possession of extensive coal-fields, which are being developed in accordance with the requirements of the trade. It is true that, in a few cases, development has somewhat outstripped demand, but taking all considerations together, there has been a steady and careful investigation of the business to be done before new mines have been opened up.

In a paper of this sort, the purely commercial aspect of the case should hardly perhaps find a place, but it is quite worthy of repetition that it is not only those mines in which the coal is of the best quality that pay for working, or indeed that return the best interest for the money expended upon them.

It will be fresh in your memories, for instance, that the coals of the Buller and Greymouth fields are of the best quality in Australasia, and that, taking everything into consideration, those of the Buller lead the van, but the conditions of transport are so difficult, or at least represent interest on such a heavy outlay, that the Brunner Mine has considerable advantages in the cheap supply of coal. In both cases the shipping ports are bar harbours, and although very great improvements in these harbours have been made by the Government, and facilities afforded for shipping the coal, they have still many difficulties to contend with ; such, indeed, that if the coal were not of the excellent quality it is, they would completely preclude the possibility of working at a profit.

Even as it is these West Coast coals cannot entirely shut out the Newcastle coals from the New Zealand markets, and on the East Coast of the South Island they have formidable competitors in the brown coals of the Malvern Hills, Shag Point, and Kaitangata; even those of Green Island, which are of very inferior quality, being able to compete in consequence of their vicinity to Dunedin, and the cheap rate at which the coal can be supplied, while Kaitangata, with a railage distance of about 50 miles, also finds a ready sale for its coal, and has been a most successful company, notwithstanding the somewhat expensive works that it has had to undertake.

In Auckland, again, the brown coals of the Waikato and Whangarei have competed successfully with sea-borne coal, and probably the best paying mine in New Zealand has been the Taupiri, although the coal was of a very inferior quality.

The Kawa Kawa Mine, at the Bay of Islands, again, was most successful for many years, but the coal there was of good quality, and being on the direct route of several ocean-going steamers, had a monopoly of that trade as long as the coal held out.

What has applied in New Zealand is equally true in Australia, for although the coals of Newcastle are the best and the field most extensive, and although the output

has been great and growing, it has not prevented the development and success of those of Illawarra, Lithgow, Lake Macquarrie, and Ipswich, in all of which the quality of the coal is inferior.

In the future, however, there can be little doubt that the principal development of the coal-mining industry will be between the Newcastle and Lake Macquarrie fields to the north, and the Illawarra field to the south; and the opening of mines below Sydney, which is only a question of time, will convert the whole district into one of the largest and probably best paying coal-fields in the world.

Mr. G. J. BINNS (Netherseal) said he would like to mention that Mr. Cox had omitted all reference to his own very considerable share in opening up and working out the geology of the Coal-measures of New Zealand. In one or two respects he had fallen into slight errors, which owing to a more recent acquaintance with the district, he (Mr. Binns) might be allowed to correct. One point he had mentioned was that the coal seams in the Buller district were 54 feet thick. When these were first examined there was supposed to be an outcrop of that thickness, but subsequent examination had proved it to be considerably less. He (Mr. Binns) thought it was probably an overlaid seam. The value of Australian coal did not depend solely on analysis, it was so hard and bore carriage so well that New Zealand coal of superior quality did not compare favourably for facility of transport, and this was somewhat against it even in its own markets. Particulars of the inclines and various other matters in New Zealand, he (Mr. Binns) had had the honour of contributing to the North of England Institute, and to these he need not now refer. With regard to the Kawa Kawa coal-field (the output of which Mr. Cox described as considerable), he would inform the meeting that owing to working troubles it was on the point of being closed. The reason why west coast coal could not drive out the Newcastle coals was to a great extent that the latter were brought from Newcastle as "back freights," in exchange for produce shipped from New Zealand. Something must be brought back, and if they did not bring coal they must bring ballast. Mr. Cox also stated that the Coal Pit Heath and Greymouth-Wallsend Pits had been shut down, but these had since been reopened.

Mr. EMERSON BAINBRIDGE (Sheffield) said it was rather difficult, without a personal knowledge of the coal-field, to discuss matters, which, however interesting and valuable, were, for the most part, descriptions of foreign coal-fields, but there were one or two points, with regard to the commercial aspect, on which he would like to say a word or two. One mark of distinction was that the limit of workable coal seemed to be so very low, and its future career could therefore be well estimated, but in Mr. Cox's paper particularly there was a somewhat peculiar anomaly with regard to the production of coal. Australian coal mining seemed to have four millstones hanging round its neck. First, there was the policy of "protection" which was pursued, and which, by its restrictions on the volume of coal produced, to some extent hindered the extension of the trade of New South Wales. Next, they had the

labour unions to contend with, and in a form which we, in this country, in our wildest notions, had little conception. There the unionism had a much more marked and stronger characteristic than with us; it was carried so far that he believed the labour representatives in the New Zealand Legislative Assembly numbered some thirty per cent. of the whole body of the Legislature. The result was that they were enabled to insist upon, and carry legislation such as would be unheard of in this country, and this formed a severe barrier to trade. A third difficulty in the way was a matter referred to in Mr. Walker's paper, the remarkable combination, in which the owners, by joining together, artificially maintained the price of coal. The result of such a policy in this country had been found to be an evil when it was expected to have been of great advantage. The fourth difficulty was the instance they had in Australia of the manner in which the State came to be the landlord, but the remarkable good that was supposed to accrue from that had failed to be experienced. He believed there were many people who think if we had State occupation of coal-fields here it would be of great good. In Australia the terms on which the State offered the coal-fields to those who chose to lease them were so low that a man would come and take up a large coal-field and hold it in his own hands; when the time came that he was to let or sell it to somebody else he exacted rather more than would have been exacted in the ordinary way if let by the occupier of the land. The effect of this, of course, would be to cause great differences in the collieries. One finds that an average over the last twenty years had produced a degree of profit unknown in this country, and no doubt, when Mr. Walker came to reply on this discussion, he would be able to give them an idea as to how the loss had been brought about in the Newcastle coal-field.

Professor A. S. HERSCHEL said he did not know if the papers mentioned the probable amount of coal in New Zealand and Australia in comparison with the English coal-fields; also the probable duration at the present rate of consumption. He believed the New Zealand coal-fields contained some 1,200,000,000 tons, as against 150,000,000,000 in England, and that the rate of output was half a million per annum in New Zealand, as against 160,000,000 tons in England. He observed that the New South Wales coal-field contained 14,000,000,000 tons of coal, or about ten times the extent of the New Zealand coal-fields. If these were about the figures he would like to hear further what figures the Queensland coal-fields might have to furnish.

The PRESIDENT said there was only one question he wished to ask Mr. Cox, and that was whether the whole area attached to the Newcastle district had been explored, because some time ago he heard there was some doubt as to whether the whole of the coal extended over that part. It was very interesting to learn that the chief town was called Newcastle, and that all the modes of thought and modes of action were similar to those in force in Northumberland and Durham. The working of the coal was the same as it used to be in these districts; and there was another circumstance, which seemed to him very curious, and that was that the very way in

which that syndicate—as the term now was—had been formed was the same as that which had previously been in force in the North. Of course it was many years ago, but he remembered it, and no doubt Mr. Bainbridge and Mr. Cochrane would remember it too, when they had what was called the "Regulation of the Vend." There was a certain volume of coal which it was supposed to be proper to produce for the demand at that time in Northumberland and Durham, and each colliery had apportioned to it a certain quantity of this. The committee who regulated the vend issued their edict that each colliery should sell so many chaldrons of coal. This system existed for many years, and had, he believed, existed long before he could remember anything about it. It sometimes happened that one colliery had its greatest sale in the summer time, and another in the winter, and from this and other causes the regulation of the vend ceased to exist. One colliery exceeded its quantity, another was short, and in the end the whole thing was broken up and was not in existence at the present time. It was very singular that all these customs should have been introduced and taken such a firm hold in Australia.

Mr. G. BLAKE WALKER said that with regard to the influence of "protection," it was clearly understood that it was by the protection principle in Victoria, amounting to something like 25 per cent. *ad valorem* duty that its manufacturing industries had been forced in an unnatural way. One result of intercolonial free trade would be the removal of the hot-house industries of Victoria to some spot on the coal-fields; and a large iron industry would spring up as soon as a certain amount of protection was commenced in New South Wales, which would no doubt be within the next twelve months, and an increase in the consumption of coal would take place. The effect of the Government owning the coal was that large areas were opened out long before there was any necessity for them. It was a misfortune for those already in the field, but a good thing for the public. With regard to the quantity of coal which might exist in the coal-fields, so far as exploration had already gone, it seemed premature to estimate it. It was not even known, as Mr. Cox had pointed out, whether the seams in the south were the same as those found in the north, or as to what existed between. He might say this without offence that Australians generally were apt to take over sanguine views of their prospects, and therefore the figures found in hand-books, etc., should be taken *cum grano*. With regard to the vend arrangement, he looked forward to its coming to a speedy end. There were a great number of collieries which must either force their coal into the market or go into bankruptcy, and if so, the vend arrangement was not likely to prevent them from underselling. Those collieries near Newcastle harbour with the thickest coal, and paying practically nothing for it, would stand a better chance than those farther away who had to pay higher rates and who had less command of labour.

Mr. COX said he thanked Mr. Binns for his corrections. That gentleman had only lately come from New Zealand and was better acquainted with the

recent workings. He was not aware that the Coal Pit Heath and Greymouth-Wallsend Mines had been reopened; he had noticed in recent official documents that the output of the Kawa Kawa coal-field had increased of late, and had hoped that a new period of prosperity was in store for these mines. He was sorry to hear that this was not so.

The PRESIDENT was sure they would accord a vote of thanks to Mr. Walker and Mr. Cox for the very valuable papers which they had read. The subject of the coal trade in Australasia was an important one, and would no doubt in future years grow to a greater extent. As to how long the coal-fields would last, he thought it was scarcely worth while making such an enquiry. They had had the same question in England, and since it was answered they had discovered many seams of coal which they never previously thought of, and there was no doubt more coal could be got now than was then stated to be the limit. He thought the same thing would apply to the Australasian coal-fields. He had pleasure in moving a vote of thanks to the authors of the papers.

The vote of thanks was unanimously accorded.

Mr. J. MCLAREN read the following paper on "The Economical Use of Steam in Colliery Engines":—

THE ECONOMICAL USE OF STEAM IN COLLIERY ENGINES.

By John McLaren.

Twenty-five or thirty years ago, mining engineers in Lancashire and the great coal-fields of Northumberland and Durham began to realize the waste of fuel which was daily going on in connexion with the steam engines in use upon the colliery works to which they were attached. The impression was, no doubt, accentuated by the high prices realized by coal during the few years of abnormal prosperity which followed the great war between France and Germany. As every ton of coal wasted represented a ton less to sell, the lesson of economy was brought home in a very practical manner in those days of very high prices. Consequently, managers were moved to try to introduce improved engines with the view of economizing their own coal as much as possible. The result was, that a large number of very fine pumping and winding engines were put down in various parts of the country. But as the steam at that time was mostly generated by the old-fashioned and wasteful egg-ended boiler, the action of the colliery engineers in putting down fine engines looked rather like beginning at the wrong end. However, the question of boilers also came to be considered, and now the egg-ended pattern is rapidly becoming obsolete, and its place is being taken by more economical steam generators. Nevertheless, there is still much room for improvement, as anyone can see who observes the manner in which steam, and consequently fuel, is wasted, by continuous blowing-off from the safety valves of colliery boilers, as well as by its extravagant use in improperly constructed engines. Although this paper is intended to deal principally with engines, the question of boilers is too important to be passed over without comment. The most useful and practical forms of steam boiler are sufficiently well known to require no detailed description. The egg-ended boiler, which happily promises to become speedily extinct, was in almost general use twenty-five years ago. Its cheapness in first cost is dearly purchased by its extravagant wastefulness of fuel. The low evaporative duty which can only be obtained from this type of boiler is due to the small amount of heating surface it presents to the action of the heated gases (viz., from 5 to 7 square feet per nominal horse-power), which thus escape up the flues at a very high temperature. An egg-ended boiler is not, as might be supposed, easily or cheaply kept in repair, and as a large percentage of them ultimately explode, causing serious loss and damage, they are in the long run the dearest type of steam boiler which can be employed. They are being rapidly displaced by Cornish and Lancashire boilers, which not only give double the amount of heating surface per nominal horse-power, but such area, consisting largely of internal flue surface, is more valuable from a steaming point of view than much of the heating surface of an egg-ended boiler. The proportion of heating surface in these boilers is about 14 square feet per nominal horse-power.

Tubular, or water-tube boilers, are largely used on the Continent and in America, and they are coming into somewhat limited use in this country. Their economy, however, is doubtful, and in actual tests a great disparity in results has been noted. the evaporation varying from 7 to 10 lbs. of water per lb. of coal; but even with the higher evaporation, their economy is not by any means established, as it is well known that their construction induces priming to a greater or less extent, so that the duty obtained from the boiler is more real than apparent. In priming, the steam of course carries a certain amount of water in the form of fine spray in suspension, which is an absolute disadvantage to the engine, though it makes the evaporation of the boiler appear very good.

The locomotive type of boiler is, however, unquestionably the best and most economical steam generator in practical use. It has also many other advantages which should have secured for it a much more general adoption than it has been hitherto accorded. It requires no expensive brickwork seating, but can be set down on a few flags or bricks laid upon the surface of the ground. The whole of its external surface can be covered with non-conducting material, which can be readily removed for complete examination and repairs. It presents at least 20 square feet of heating surface per nominal horse-power. It can be stayed so as to be absolutely safe at pressures up to any practical limit. It occupies the least space of any boiler in proportion to its power, and gives the extremely high evaporative duty of over 11 lbs. of water per lb. of coal. They can be made up to 100 nominal horse-power each. There is an unreasonable prejudice against these boilers in the minds of some steam users, owing to their supposed greater wear and tear, though in practice they will be found to cost no more in the long run for repairs than Cornish or Lancashire boilers doing equal duty. The efficiency of a boiler is estimated by the rapidity with which it generates steam, and the smallness of the amount of the fuel with which this result is attained. Measured by this standard the locomotive type of boiler must take the very first place.

The evaporative efficiency of the different types of boiler may be stated approximately as follows:—

Egg-ended boilers	4·6	lbs.	of	water	evaporated	by	1	lb. of coal from and at 212° Fahr.
Lancashire	„ 8	„	„	„	„	„	„	„
Tubular	„ 7 to 10	„	„	„	„	„	„	„
Locomotive type	11	„	„	„	„	„	„	„

The most perfect boiler and the best steam engine are, however, but clumsy and extravagant instruments for the conversion of heat into work. Each pound of good Welsh coal contains over 16,000 units of heat. Each unit of heat is theoretically equal to 772 foot-pounds, so that the theoretical value or duty of 1 lb. of coal is 12,537,280 foot-pounds or about 6½ horse-power per hour. Hitherto it has been found impossible to construct engines and boilers capable of giving off anything like the amount of work corresponding with the theoretical value of the coal. In the best authenticated experiments the highest economy attained has been one horse-power for a consumption

of 1·35 lbs. of coal, or only about 11·75 per cent. of its theoretical value. But as the vast majority of high pressure steam engines are burning from 5 to 8 lbs. of coal per indicated horse-power they are only utilizing about 2 per cent. of the theoretical value of the coal! This loss is sufficiently serious without its being unnecessarily increased by continuously blowing off steam from the safety valves, losing heat by radiation from uncovered boilers and steam pipes, or allowing boilers to prime, and thus wasting water and heat and damaging the engine at the same time.

It is manifest that the waste of fuel supplied to the steam engines of this country must be measured by millions of pounds sterling per annum; so that it is to the interest of all users of steam power (colliery owners included), to economize wherever possible. Mechanical engineers have, therefore, in recent years devoted much attention to the design of high class steam engines and boilers in which the waste shall be reduced as much as possible. Some of these designs have involved much complicated mechanism for the working of the valves, which, while effecting to a greater or less degree the desired end, have introduced another element of expense and waste in the complication of the mechanism required.

Many claims to extraordinary economy have been put forward on behalf of one or other of these various forms of engines or valve gearings, but unless the figures so given are vouched for by a qualified and independent engineer they must be received with the utmost caution. The omission, intentional or otherwise, of what might appear trifling observations might easily make all the difference between a phenomenally good and a merely average result. Instead of instituting comparisons, however, which could scarcely fail to look invidious, it may be better to refer to a series of trials which were carried out in the works of the author at Leeds, with a set of triple-expansion engines, from which very remarkable results were obtained. There was nothing special in the design or construction of the engine, except that the greatest attention and care had been bestowed upon the proportions of the various parts. The figures would appear to show that where sufficient care in construction is exercised the same economy can be obtained with engines and valve gear of the stereotyped pattern as has been considered only obtainable with complicated and expensive valves and valve mechanism.

The difference, for instance, which a proper proportion of steam passage will make is simply incredible. A case came under the notice of the writer a short time ago, in which the steam ports of a compound locomotive by one of our best British makers were so small, that the *power absorbed in expelling the exhaust steam* from the low pressure cylinder amounted to about 10 per cent. of the whole power of the engine. The ports were so small that after the steam had done its work in the cylinder, it could not escape fast enough to keep out the way of the piston on its return stroke, consequently the latter, impelled by the higher pressure on the other side, had to act as a force pump, forcing out the steam, which of course exerted a considerable back pressure, and absorbed a proportionate amount of the useful energy of the engine. See Figs. Nos. 1 and 2, 3 and 4 (Plate XXIX.).

EXPERIMENTS UPON A TRIPLE-EXPANSION ENGINE.

The triple-expansion engine and locomotive boiler upon which the following experiments were made was one of three exactly alike, constructed to the order of the Central Argentine Railway Company, for the electric lighting of the workshops, etc., at Rosario. They are, of course, equally suitable for any other class of work, such as driving ventilating fans, pumping, compressing air, or other continuous work at coal or other mines. As coal at Rosario costs 70s. per ton, the advantage of economical engines is obvious. The engines in question were of the vertical inverted cylinder pattern, marine style, surface condensing, with cylinders 9 inches, 14¼ inches, and 22½ inches diameter by 2 feet stroke, working down on a three-throw crank set at angles of 120 degs., the high pressure crank leading. The high pressure and intermediate cylinders are jacketed with live steam supplied direct from the main steam pipe. The condensed water from the jackets is allowed to escape through Macdougal patent steam traps, and was carefully measured at the trial. The slide valves are what is known as the trick pattern, being a modification of the well-known D-valve. They are each worked by a single eccentric from the crank shaft. The admission of steam to the high pressure cylinder is regulated by the McLaren improved governor and automatic expansion arrangement combined, by which the steam can be cut off at any point from 0 to ·75 of the stroke, the lead remaining constant, notwithstanding variations of the cut off.

The condenser is fixed horizontally at the back of the engine, and consists of an upper and lower division separated by a diaphragm plate, but connected at one end so that the exhaust steam is well distributed amongst the condenser tubes. These are of brass, communicating with water boxes at each end, and the water for condensing circulates through the inside of the tubes, the exhaust steam being brought into contact with the exterior surface. Air pump, circulating pump, and feed pumps are fixed behind the condenser, and worked off a crosshead which is driven by a couple of sway beams worked off the crosshead of the intermediate piston rod. The whole of the oiling of the moving parts is done from the platform at the back of the cylinders, and is arranged so that the engines can work continuously without stopping for oil.

As it was intended to make exhaustive trials of these engines, the fly-wheels were made with a groove or trough inside the rim, into which cold water could be run to prevent the rim of the wheel getting too hot by the friction of the brake. Automatic skimmers were fixed in such a position as to carry off the superfluous water from the fly-wheel rim. Indicator gear was fixed on each cylinder, but instead of one indicator being fixed at each end of each cylinder, only three instruments in all were used, viz., one on each cylinder. T-pipes were used, one branch being carried to the top and the other to the bottom, the indicator being fixed on the centre. This was very unfortunate, as a considerable loss of indicated power was thus sustained. It has been found by actual experiment that this arrangement may involve a loss of as much as 8 per cent. as

compared with having the indicators close up to their work at each end of the cylinder. Unfortunately, at the last moment, although plenty of indicators were at hand, it was found that several springs were wanting, and as it was not convenient to postpone the trial, the best had to be made of the apparatus immediately available. The boilers are of the multitubular type, steel throughout, barrel 4 feet 10 inches diameter, 11 feet 1¼ inches long, over tube plates, containing 106 tubes, and presenting 880 square feet of heating surface with 26 square feet grate area. It was fired by hand. The whole was covered in to prevent as far as possible any loss of heat by radiation. As the results obtained in previous trials with the same engine were so exceptionally good, it was determined to ask Professor Goodman, of the Yorkshire College, and Mr. Wilson Hartnell, of Leeds, to run an independent test, so that the figures published might be accepted as above suspicion. These gentlemen accordingly took charge of the engines for a four hours' run, and with a large staff of their own assistants made a complete test, from which the following figures and remarks are copied :—

Indicator diagrams were taken at intervals of 15 minutes by means of Crosby indicators, which were driven in the usual method by quadrants attached to a rocking shaft. The springs used were $\frac{1}{150}$ for the high pressure, $\frac{1}{70}$ for the intermediate, $\frac{1}{35}$ for the low pressure cylinder.

The brake horse-power was measured by means of a brake, consisting of a broad colliery rope, 6 inches wide, wrapped round the upper half of the fly-wheel; from one end of this rope a dead-weight (946 pounds) was suspended, the other end being provided with two Salter spring balances. The equivalent load on the brake was 940·35 lbs., acting at a radius of 4·91 feet. A jet of water was allowed to play into the trough-sectioned rim of the fly-wheel in order to keep it cool. The brake, which ran remarkably steady during the whole trial, was occasionally lubricated with a little tallow.

The feed-water was measured by means of two tanks which were previously gauged by filling with weighed water of the same temperature as the feed.

The jacket water was also measured in a separate tank, gauged in a similar manner to the feed-water tanks.

There was a loss of some 6·92 per cent. between the feed-water supplied to the boiler, and that obtained from the hot-well, the balance made up by an auxiliary supply weighed in the same manner as the feed and jacket water. This loss, we may add, is always found in surface-condensing engine trials, and does not show that any error occurred in the measurements.

The revolutions of the engine were recorded by a Harding counter, and were checked by counting once in every quarter of an hour. The mean revolutions thus obtained agreed perfectly with those recorded by the counter, the speed was remarkably constant, the revolutions only varying between 120 and 122 per minute during the whole trial. The coal was carefully weighed out on a new Denison weighing machine, and supplied to the firemen in boxes containing 112 lbs. each. The

amount of fire on the bars was estimated at the beginning and brought to, as near as possible, the same condition at the end of the trial. A sample of the coal was dried, but it was only found to contain an inappreciable quantity of moisture.

The water in the gauge glass was carefully noted at the beginning of the trial and brought up to the same point at the termination.

The temperature of the escaping gases in the smoke box was taken at intervals, also the amount of draught by means of a water-gauge.

Everything in connexion with the engine and boiler went remarkably smoothly and regularly, during the whole trial, which lasted about four hours.

Before commencing the trials all the pipe connexions and valves were carefully examined to ensure that no leakages or other irregularities should occur. The engine was allowed to run for about one hour before the actual trial took place. Observations were taken every quarter of an hour by our own staff of assistants. The purchasers of the engine also had a staff of their own taking similar observations quite independently of our own. The indicator cards have all been measured twice by means of a planimeter, and the whole calculations carefully checked. The results of the trial were as follows:—

1.—Duration of trial			4·1 hours.
2.—	Indicated horse-power	High pressure cylinder, 39·27... ...	121·85 I.H.P.
3.—		Intermediate cylinder, 42·04... ...	
4.—		Low pressure cylinder, 40·54... ...	
5.—Brake horse-power			106·9
6.—Mechanical efficiency, per cent.			87·7
7.—Revolutions per minute			121·6
8.—Steam pressure in boiler (above atmosphere)			157 lbs. per sq. inch.
9.— „ „ absolute			171·2 „
10.—Vacuum in condenser			28 inches.
11.—Feed-water used per indicated horse-power per hour including jackets			13·6 lbs.
12.—Feed-water used per brake horse-power			15·5 „
13.—Steam used in jackets per indicated horse-power per hour			1·24 „
14.—Steam used in jackets per brake horse-power per hour			1·41 „
15.—Coal burnt per indicated horse-power per hour ...			1·35 „
16.— „ exclusive of ash			1·33 „
17.— „ per brake horse-power per hour			1·53 „
18.— „ exclusive of ash			1·51 „
19.—Water evaporated per lb. of. coal from a mean temperature of 110 degs. Fahr.			10·11 „
20.—Water evaporated per lb. of coal from a mean temperature of 110 degs. Fahr., exclusive of ash ...			10·26 „

21.—Water evaporated per lb. of fuel from and at 212 degs. Fahr.	11·34 lbs.
22.—Water evaporated per lb. of fuel from and at 212 degs. Fahr., exclusive of ash	11·51 „
23.—Coal burnt per square foot of heating surface per hour	0·186 „
24.—Mean temperature of smoke box	460 degs. Fahr.
25.—Vacuum in smoke box	½ inch of water.
26.—Heat taken up by feed-water per minute	29,930 thermal units.
27.—Heat turned into work per minute	5,206 „
28.—Thermal efficiency of engine	17·4 per cent.
29.—Heat rejected in circulating water per minute ...	23,400 thermal units.
30.—Difference due to radiation, etc.	1,164 „
31.— „ „ per cent.	8·89 „

It may be of interest to note that the weight of steam shown by the indicator cards in the three cylinders is approximately 0·079 lb., 0·090 lb., and 0·068 lb. at the beginning, and 0·080 lb., 0·092 lb., and 0·074 lb. at the end of the stroke in the high pressure, intermediate, and low pressure cylinders respectively; the weight of feed-water used per stroke was 0·114 lb.

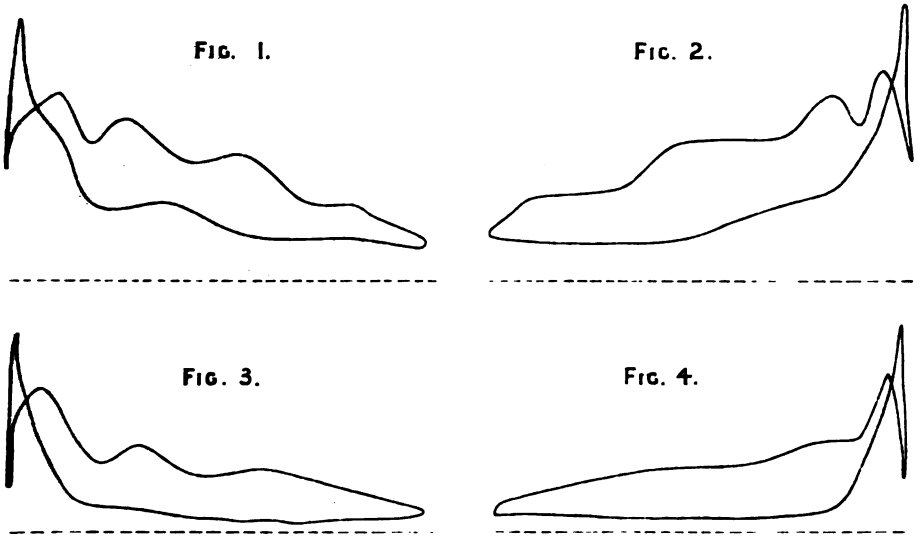
Figs. 5 to 10 (Plate XXIX.) show copies of the indicator diagrams, 5 and 6 are from each end of the high pressure cylinder, 7 and 8 the intermediate, and 9 and 10 the low pressure. Fig. 11 (Plate XXX.) shows the combination of the three cards and their relation to the theoretical curve, which is shown by the dotted curved line. The influence of the jacket is shown very plainly in this diagram, for while the actual line almost coincides with the theoretical line in the case of the jacketed cylinders, it falls considerably short of it in the case of the low pressure cylinder, which was not jacketed at all.

Mr. WM. COCHRANE asked whether the character of the coals differed in the experiments from which the tabulated results given in the paper were taken? When Mr. Wm. Armstrong, Jun., made some experiments of this kind (which formed the subject of a recent paper), the very smallest duff coal was used. Were the coals in this instance the best steam coals that could be got?

Mr. MCLAREN replied that the coal used in the tests of which he had given the particulars was Ebbw Vale, with a calorific value of about 16,000 units. As small coal was used in Mr. Armstrong's experiments, there was no doubt some difficulty in arriving at an exact comparison In the absence, however, of reliable data respecting the best coal used in connection with egg-ended boilers, he had given what he considered a fair average, making a liberal allowance for the fact of very small coal having been used under the old-fashioned boilers. In all future researches it was desirable that the experiments should be made with coal of a known calorific value.

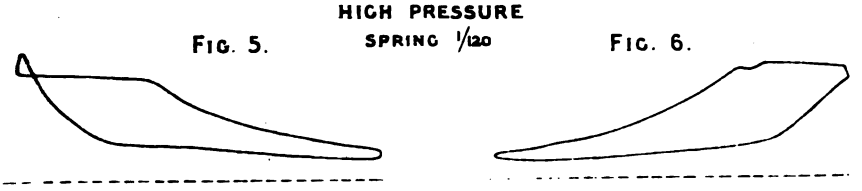
To illustrate Mr. John McLaren's paper on "The Economical Use of Steam in Colliery Engines."

DIAGRAMS FROM COMPOUND LOCOMOTIVE.

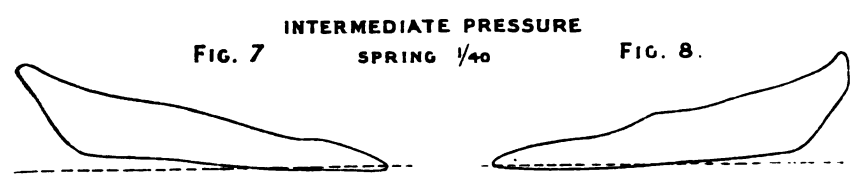


DIAGRAMS FROM TRIPLE EXPANSION ENGINE.

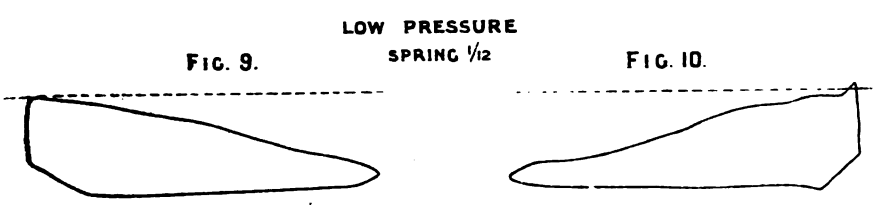
HIGH PRESSURE
SPRING 1/120



INTERMEDIATE PRESSURE
SPRING 1/40



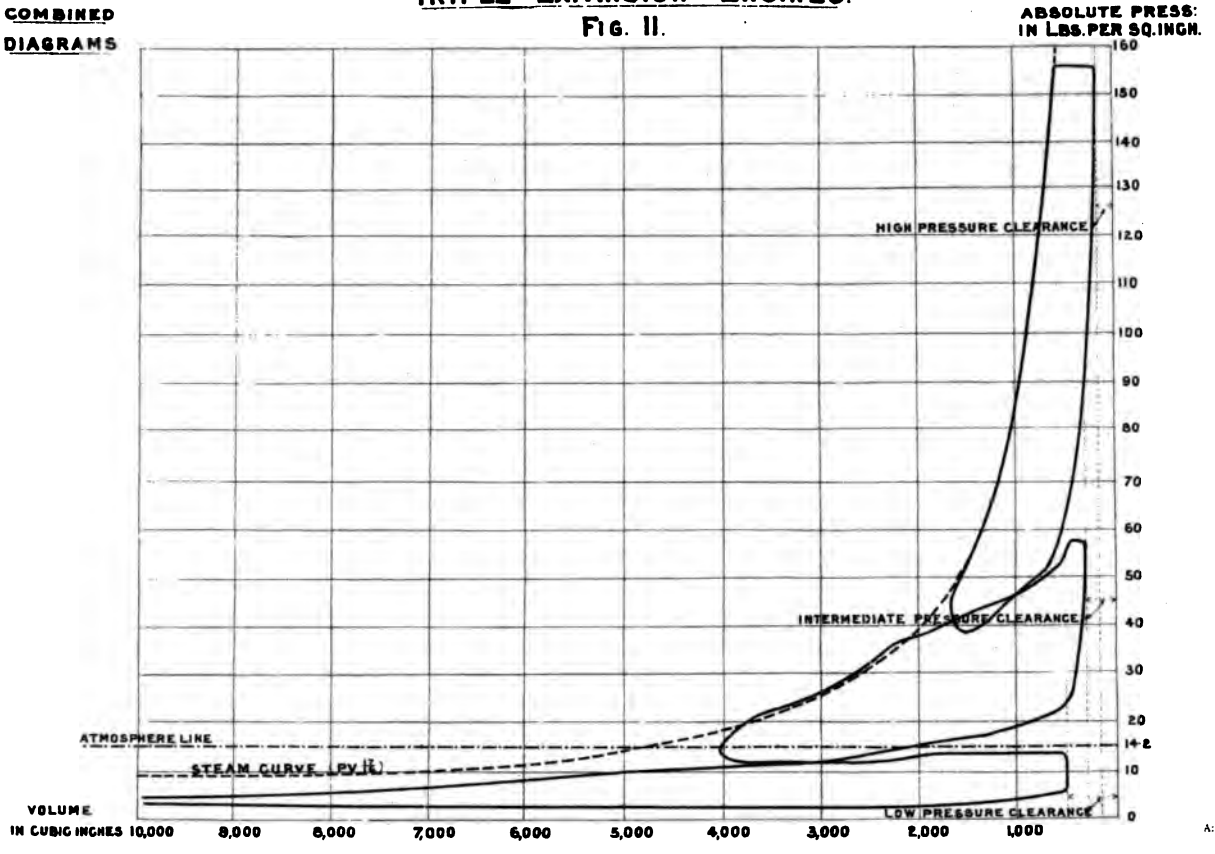
LOW PRESSURE
SPRING 1/12



THESE DIAGRAMS ARE HALF-SIZE

TRIPLE EXPANSION ENGINES.

FIG. II.



And.w Reid Sons & Co Lithos Newcastle

Mr. LONGDEN said his experience bore out the evidence given as to the difference in evaporative power between an egg-ended and a Lancashire boiler. The most economical arrangement, he believed, was to use Dowson gas in a gas engine.

Professor HERSCHEL asked if the reflective indicator had come before the notice of the writer of the paper? It was coming into use, and had been lately tested at the Finsbury Technical College.

The PRESIDENT moved a vote of thanks to Mr. McLaren for his paper.

Mr. COCHRANE seconded the motion, which was cordially adopted.

In the absence of the authors, Mr. M. WALTON BROWN read the following paper, by Mr. James Ashworth and Professor Clowes, on "The Detection of Fire-damp":—

THE DETECTION OF FIRE-DAMP.

By James Ashworth, M.E., and Professor F. Clowes, D.Sc., etc.

I.—Remarks on Safety-Lamps.

Ever since Sir Humphrey Davy invented the safety-lamp which still bears his name, the Davy has been the principal lamp used by colliery officials for making their daily and constant search for their silent and insidious enemy, fire-damp. It has, however, for a long time been known that our old friend is not sensitive enough to detect the small percentages of gas which in a dry and dusty mine render the ventilating current positively dangerous.

Thus, at the enquiry into the Seaham disaster in 1880, it was stated that the presence of 2½ per cent. of fire-damp in a dry and dusty mine created an atmosphere which would in the presence of a blown-out, overpowdered, or badly-placed shot, bring about a fearful disaster; and yet no lamp then in use would show a trace of such a percentage. It is almost equally true to say so still, as the generality of lamps used by deputies and firemen will not trace 2 per cent. of fire-damp.

In 1880 Mr. James Ashworth contributed a paper to the North of England Institute of Mining and Mechanical Engineers on "Improved Safety-Lamps of the Davy and Mueseler types" (Transactions, Vol. XXIX., page 145), in which he gave details of tests on Davy lamps with gauzes of different diameters, and particularly on those of an unshielded Davy, which proved that the flame would readily pass through the gauze in a current of air moving at a velocity of 6 feet per second if only 4½ per cent. of gas were present, and so much coal-dust as the air current could lick up from the floor of the test box. Thus, such a mixture was found to be explosive, although, according to the table of caps recorded in Mr. M. Walton Brown's paper on the "Pieler Spirit Lamp" (Transactions of the North of England Institute of Mining and Mechanical Engineers, Vol. XXXVIII., page 177), 4½ per cent. of fire-damp should only have given a cap of 4½ inches. It has since been shown that so little as 1 per cent. of fire-damp when mixed with the ventilating current of a dry and dusty mine is positively dangerous, and it therefore behoves us to place ourselves in a position to discover these small percentages. Again referring to Mr. Brown's paper, it will be seen that the Davy lamp is credited with a cap nearly a quarter of an inch high in the presence of 2 per cent. of fire-damp, the Wolf lamp, burning benzine, one of ·43 inch high and the Pieler spirit lamp 5½ inches high, whilst Professors Kreischer and Winkler (Transactions of the North of England Institute of Mining and Mechanical Engineers, Vol. XXXV., page 3) give the heights of flame and cap as under:—

Lamp.	Normal Height of Flame.	Percentage of Fire-damp.	Height of Cap with Normal Flame.	Reduced Flame.
Wolf lamp, burning benzine...	·98	—	—	—
Air admitted below the flame...	—	2	·27	·39
Air admitted above the flame...	—	2	·20	·35

It would appear from this table that the coolest flame gave the largest cap; and, as this is contrary to all teachings with either the Pieler or hydrogen flames, the results cannot be received with confidence. On reference to the drawings of the lamps tested, it is seen that the gas given off by the heated spirit within the reservoir escapes close to the flame, and therefore produces a false cap.

In the lamps now described, this point has received special attention, and all gas produced within the reservoir is allowed a free escape outside the lamps through the tube (Fig. 2, Plate XXXI.), which has no valve, excepting only the pressure of the atmosphere; consequently, as soon as evaporation takes place, the resultant gas escapes after overcoming a slight amount of friction, and its natural tendency to ascend rather than descend.

Likewise, if the vessel be overfilled, the excess of spirit escapes to the outside of the lamp instead of being forced up the wick tube, or through the filling hole (where this is covered by a simple shutter) into the combustion chamber of the lamp. The danger arising from pressure within the reservoir will be well understood by all those who have used the Pieler alcohol spirit lamp.

The burner is constructed as an Argand burner, with a slide operated by a screw to regulate the height of the wick flame, and the inside air tube projecting above the wick to prevent any excess of spirit filtering over, and also to make the reduced flame quite blue and non-luminous.

The burner is surmounted by a conical continuation of the glass ring, which brings all air entering the lamp into close contact with the wick flame.

The air ring is constructed with a rectangular groove cut around the air holes bored through the ring, surmounted by the glass ring, which is screwed to its upper and inner edge, thus securing the covering gauze in its place and facilitating cleaning.

The glass is conical in form and ground dead over two-thirds of its inner surface to completely deaden all reflection—when testing for gas. For low percentages it is an advantage to colour the outer surface of the ground part, as the eye is thus assisted in defining the gas cap. In the tests to be referred to, vermilion was the colour used.

The conical gauze is of very small dimensions, but is large enough for the products of combustion to escape through it freely. It is surrounded by a cylindrical shield, and surmounted by a cone, which is part of the top frame of the lamp. The shield and cone thus form a Mueseler chimney outside the gauze, and so combined completely protect the latter from all currents, no matter what their velocity

may be, and also keep it in a warm bath, and ensure it a much longer life than that of the gauze of any other lamp.

The shut-off is placed over the inlet tubes and within the hood, and is operated by a stud which projects under the top frame of the lamp.

The air enters and finds its exit through the hood, which protects the inlet tubes and the outlet cone from *débris*, and also from the direct effects of the ventilating current, whatever its direction may be. It also equalizes the pressure on the inlet and outlet air currents, and thus secures a steady illuminating flame.

Generally, the lamp is of the type invented by Mr. Gray, M.E. and C.E., formerly one of H.M.'s Assistant Inspectors of Mines, and it is one of the four types of safety lamps recommended by the late Royal Commission on Accidents in Mines, as being quite safe in explosive mixtures of fire-damp and air, and also for its great adaptability to gas-testing requirements.

The inlet tubes are three in number, consequently the rays of light from the flat side of the wick flame of an oil burner can always find a full outlet. One or more tubes are provided with a hole at the base, which can be covered or uncovered at will by a loose sleeve.

When testing for fire-damp, either one or both the shutters over the holes near the base of the inlet tubes are pushed up and the holes left wide open.

The deputy then raises the lamp, without lowering the wick flame, until the spiring up of the latter indicates the presence of gas, or the lamp reaches the roof or highest part of the working.

If no gas is found in this way the holes are gradually closed by the thumb and forefinger of the hand holding the lamp, and any small percentage of fire-damp will then be indicated as above described.

It was hoped that the lamp would be successful in detecting low percentages of fire-damp with the ordinary oil flame, viz., by its elongation, but the indications are not perceptible under 2 per cent. The reduced oil flame will show 2 per cent. better, it is thought, than the full flame, mainly because the non-luminous flame becomes slightly luminous, with a trace of cap in the presence of 2 per cent. of fire-damp.

The principal desideratum, therefore, in finding fire-damp when present in less quantity than 2 per cent. is a hot non-luminous flame, and to meet this requirement a lamp with two burners was tried, one for alcohol and one for oil, otherwise one for testing (non-luminous and hot) and the other for illumination only. This arrangement was found too cumbersome and complex for pit requirements, and benzolene was decided on as giving an excellent light, and when reduced (with the burner previously described) it produces a hot non-luminous flame.

As volatile illuminating agents are looked on with great suspicion by a large number of mining engineers it will not be out of place to state that benzolene burns with a flame of great luminosity, and also that in burning no separation of carbon takes place, but the luminosity may be increased or lessened by the metal of which

the burner is made—for instance, if the metal be a good conductor of heat, the non-luminous part of the flame will be larger than if the burner is made of a metal which is a bad conductor of heat—otherwise the latter gives the best illumination.

Benzolene requires a smaller volume of air than rape oil to produce perfect combustion.

A benzolene flame may be reduced until it becomes permanently non-luminous, but a rape oil, or a mixture of rape and petroleum cannot be so reduced, as a residue of carbonaceous matter is always being formed, and leads to irregularity in the character of the flame. The benzolene flame is also superior to either of the other two for testing low percentages of fire-damp, and the mixed oil is better than pure rape.

The sensitiveness of a flame in the presence of fire-damp depends on its non-luminosity and its heat; this is very clearly demonstrated by a hydrogen flame.

II.—Account of Tests made on Safety Lamps.

The apparatus which was specially designed for ascertaining the delicacy of the lamp as an indicator of gas, is described below. (Fig. 3, Plate XXXI.)

The chamber containing the mixture of gas and air was a wooden box; this was supported on legs, which raised it to such a height that the lamp in the chamber, when observed through a glass plate in front, was on a level with the eye. The box was made perfectly gas-tight by melting paraffin wax over its surface, and then passing a hot flat iron over the wax. The box was provided with an upper inlet tube for introducing the fire-damp, and with a lower exit tube for the escape of the air which the gas displaced; both tubes could be opened and closed at will, but the outlet tube was usually sealed by merely allowing its end to dip just beneath the surface of some water. In the bottom of the box a flanged opening was made, large enough to allow of the introduction of the lamp; this opening was sealed by pushing up against it a metal tray containing water, into which the flange dipped to the depth of about one inch; the tray was supported by turning round two flat buttons, which passed beneath it on each side.

To hasten the mixture of gas and air, a light wooden board, nearly as large as the section of the box, was suspended near the side of the box, upon a horizontal axis; the ends of the axis passed air-tight through the sides of the box; and one end of the axis was keyed to a handle, by which the wooden board could be readily swung up and down in the interior.

The whole surface of the interior of the box and of the mixing board was painted dead black.

The internal capacity of the box was 95·22 litres, or 95,220 cubic centimetres. Accordingly, it was necessary to introduce 952 cubic centimetres of gas to make a 1 per cent. mixture, and simple multiples of that volume for the larger percentages.

The gas was made by the ordinary chemical process for the preparation of methane, and was well washed with caustic soda solution to free it from carbonic

acid. It was stored in a glass gasholder, which was then connected by flexible tubing with the upper inlet to the chamber, the air contained in the flexible tubing having first been displaced by the gas. The measured quantity of water—equal to the volume of gas to be introduced into the chamber—was poured into the upper part of the gasholder; and this water was allowed to force its own volume of gas into the chamber as it flowed into the lower part of the gasholder. As soon as no more air bubbled out through the water from the exit tube of the chamber, the gas and air were thoroughly mixed in the interior of the chamber by flapping the shutter up and down for a short time. The lamp was then quickly introduced from below, and the water seal restored. As soon as the appearance of the flame became permanent —usually in a few seconds—the dimensions and character of the cap were noted.

After a test had been completed, the contents of the chamber were replaced by fresh air by blowing a powerful stream of air into the top of the chamber from below by bellows.

That this method of working gave trustworthy results was proved by the appearance of the cap remaining unchanged when an ordinary testing lamp flame was burnt in the chamber for a quarter of an hour, even when the lamp was frequently removed and reintroduced during the interval. And further, it was found that the large cap of the Pieler corresponded with each percentage to the appearance and dimensions described with the same percentage by its inventor. The method here described, while being trustworthy, has the advantage of securing great economy of gas, and, therefore, enables the tests to be made with marsh gas, chemically prepared and purified, without incurring undue trouble and expense.

The modified Hepplewhite-Gray lamp, as described, showed extraordinary sensitiveness to gas. The effect of 0·25 per cent. of gas on its flame was distinctly appreciable.

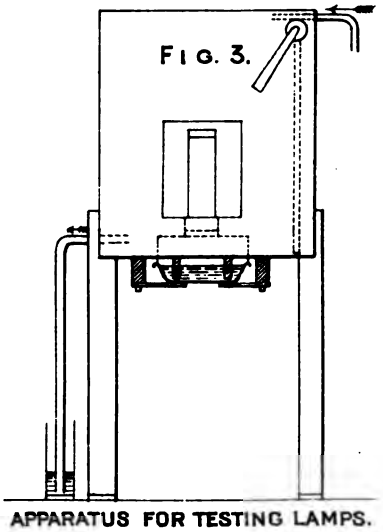
With 0·5 per cent. there was a cap 7 millimetres (0·28 inch) in height, but its top was hazy and somewhat difficult to estimate with precision.

With 1	per cent.	the cap	became	...	10	millimetres	= 0·39 inch.
„ 2	„	„	„	about	15	„	= 0·60 „
„ 3	„	„	„	...	20	„	= 0·79 „
„ 4	„	„	„	...	25	„	= 0·98 „
„ 5	„	„	„	...	30	„	= 1·18 „

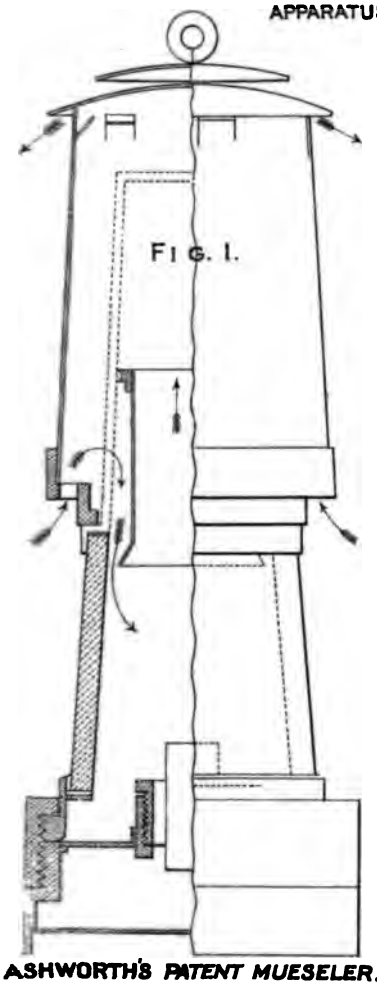
With each increase in the proportion of gas, the upper part and edge of the cap became better defined, and with the higher percentages the definition was extremely sharp.

The indications exceed those of any lamp we have tested except the Pieler. The sensitiveness is partly due to the almost total absence of luminosity in the pale blue flame produced by lowering the wick in the benzolene lamp. An oil lamp never gives a similar flame with any certainty and for any length of time. There is little doubt that the benzolene flame is also hotter than an oil flame, and hence tends to give a more visible cap. With regard to the Pieler, it labours under the disadvantage of being unable to give an illuminating flame for ordinary use in the pit; whilst

To illustrate Mess^rs James Ashworth & F. Clowes' paper on "The Detection of Fire Damp".

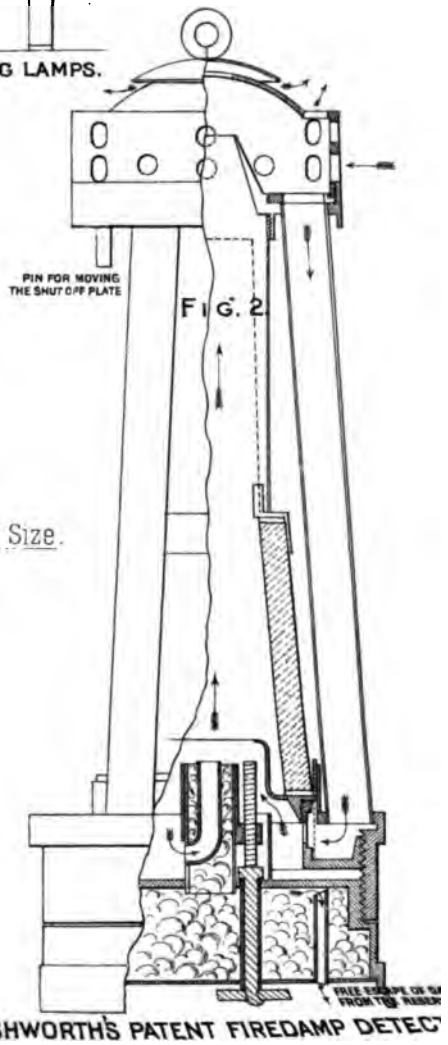


APPARATUS FOR TESTING LAMPS.



ASHWORTH'S PATENT MUESELER.

Scale: Half Size.



ASHWORTH'S PATENT FIREDAMP DETECT

the benzolene lamp gives a flame of admirable brilliancy and steadiness when the wick is turned up. It will be seen from the construction of the lamp we have been experimenting with, that the introduction of benzolene vapour into its interior from the reservoir is impossible; and further, that the adjustment of the wick is rendered easy and certain by means of a screw of very low pitch which raises and depresses it.

Mr. W. SPENCER (Leicester) said the lamp described was undoubtedly a very good one for the detection of gas, but one very important drawback to it was that it was very easily put out. Another drawback was the very intense heat of the top of the glass. The glasses did not often break, he would admit, but the heat was intense, and he had sometimes thought a drop of water falling on the glass might cause a fracture; the chief drawback of the lamp, however, was its liability to go out under varying circumstances.

Mr. M. WALTON BROWN said he had tried the lamp, but as a gas-testing lamp he would certainly advocate the use of the Pieler. With that lamp ¼ per cent. of gas gave a flame about 2 inches high, and it was much more clearly seen than on some of Mr. Ashworth's lamps. When they had as much as 2 per cent. of gas present the Pieler lamp gave a brilliant flame which had been described as "glowing like a furnace." As a gas-testing lamp the Pieler, enclosed in a tin case to keep it free from currents, and in the hands of a careful person, was the best lamp they could get. It was not suitable for use where the percentage of gas exceeded 1½ to 2 per cent. It was very sensitive to draught, and it was necessary to protect the lamp with a suitable shield. After a place was found to be free from gas with the ordinary Davy lamp its presence could be frequently detected with the Pieler. On two or three occasions he had been testing air-currents for gas, and by means of the Pieler lamp had found gas on intakes where its presence was otherwise unsuspected; in one case recently he took a sample of the air and had it examined by a chemist, who confirmed the test exactly.

Mr. J. HUGHES said that the lamp exhibited was one of those which Mr. Ashworth called his "latest pattern," and possessed a great advantage over those of earlier manufacture, inasmuch as it was not so liable to go out. The holes in the crown of the first lamps were not sufficiently protected by the rim, which should project sufficiently far to completely cover them. As a result they were directly exposed to the current, and easily went out. In the later lamps the rim was larger, and the lamp was not so easily extinguished. A great point in favour of the lamp was that, in addition to its gas-testing qualifications, it gave a good light. A great objection to the Pieler lamp was that it was simply a gas-tester, and they might just as well use a Liveing indicator. The obscuring of part of the glass was a decided advantage, and enabled one to see the slightest cap of flame very easily. He had tried one now for four or five weeks in the hands of a foreman, with satisfactory results. Of course a good deal depended on the man being used to the lamp; but with a little care the man now seldom lost his light.

Mr. M. WALTON BROWN said he would like to ask Mr. Hughes, in connection with the use of Mr. Ashworth's lamp, if he could give the lowest percentage of gas which it could detect?

Mr. HUGHES said he had not used the lamp for the purpose of detecting any percentages of gas; he had tried it by putting it in the hands of the man who had to work with it. Experiments with safety-lamps conducted in rooms like the one they were now speaking in, and by persons like themselves with clean hands, were no guide for the work to be done by a man with dirty hands in such places as return air-ways. Many lamps which gave excellent results in trials, were practically no use down the pit; they would not burn.

Mr. M. WALTON BROWN—You are speaking of the Ashworth lamp as a lamp, not as a fire-damp detector.

Mr. HUGHES—I do not wish to say that it will detect gas as well as some of the delicate indicators will—such as I call the Pieler lamp, which is not a safety-lamp but a gas indicator—but it will certainly show gas where no other safety-lamp will.

Mr. SPENCER said he could quite corroborate what the last speaker had said. They could find gas with this lamp when they could not do so with the Davy, Mueseler, or other lamps, and the reason of this was that these other lamps did not find the gas unless they were lifted into it, whereas the Ashworth lamp, getting its air from the top, brought the gas down.

Mr. HUGHES begged to differ from this statement, because he had tried an ordinary safety-lamp by covering it with a case, and carrying from this a tube so as to enable it to take the air from places equally as high as the Ashworth, but this lamp would detect smaller percentages than any other, probably due to the fact that the mixture passes direct to the flame from beneath, while in other types the inlet is above the flame.

The PRESIDENT said he had in mind the Grey lamp, which he thought was invented in Wales some time ago, in which the four pillars which supported the top were open, and supplied air to the lamp below; and this was used for detecting gas so that they could get close to the roof.

Mr. SPENCER—This is the same pattern of lamp.

Mr. M. WALTON BROWN—It is a modification of the Grey lamp.

The PRESIDENT thought they should pass a vote of thanks to Mr. James Ashworth and Professor Clowes for their paper. It was very necessary that they should all know of these things, and especially to go into such minutiæ as they had gone into that day.

The proposal was heartily carried.

Mr. HAYWARD proposed a vote of thanks to Mr. Embleton for presiding; it was a great pleasure to have him present.

Mr. SPENCER seconded, and the vote was carried with acclamation.

Mr. EMBLETON said his services that day had been more routine than anything else; but if they had met with the satisfaction of the meeting, he was delighted.

The meeting then adjourned.

DINNER AT THE HOLBORN RESTAURANT.

THE PRESIDENT OCCUPIED THE CHAIR.

After the usual loyal toasts Mr. ARTHUR SOPWITH proposed "The Federated Institution of Mining Engineers." He wished the Institution all success. The number of members present at this meeting was in itself a sufficient guarantee of the interest which was taken in the Institution, and with the papers which had been read that day all tended to show that everybody was desirous that the Federated Institution should be a success. He would just like to express the views they must all have in proposing this toast, and that was that they hoped before long they would become a most influential body by inducing other institutes to join with them, and that they would assume a status which would be truly worthy of the mining industry and the mining interests of this country, which was really that of the whole world, and he hoped this Federated Institution would grow into something which would be representative, emphatically representative, of that industry. He could only congratulate the Federated Institution on having the President with them that day. The day's proceedings had recalled a more remote past than probably many of them could recollect; it was, at any rate, much before his (Mr. Sopwith's) time. And the President had shown them in a very comprehensive glance the immense strides mining had taken. It was very interesting and very satisfactory to them to have at the head of the table that night a gentleman who represented truly the mining industry or the coal industry of England. He coupled with the toast the health of their President.

After the toast had been duly honoured,

The PRESIDENT said he was very much obliged to them for the way in which the toast had been received, and he would simply thank them for the toast and the proposals for his own health. When they reflected on their labours, they would see clearly that without the mining engineer there would be no industries in the world. Coal was the motor that worked their steam engines, and the steam engine was used to drive everything else, and they would see that unless they had coal, no manufactories could succeed. In some places they had water-power; but while water-power sometimes failed in dry weather, so long as there were mining engineers, coal would never fail. If they had had a waterfall like Niagara or that of Trollhattan in this country, they might, perhaps, have done without coal; but they had not these advantages, and every person therefore fell back upon coal. He was very pleased to think that he had brought to their remembrance the things which happened when, perhaps, some of the gentlemen at his left were not thought of, but he did not think there were many mining engineers of the present day who would do what

he and others had to do in the old days. They had now a cage to go up and down the shaft in; they would not care to put their leg through a loop and swing in the shaft with only a yard stick to guide them from bumping against the side; not many mining engineers would do that nowadays, but he got so accustomed to it in his apprenticeship days, that he would think no more of going down a pit 600 yards deep in that way, than he would of getting his breakfast. Use was second nature, but no doubt the mining engineers would prefer the present mode of getting down a pit to the old rough way. Again he thanked them for the toast, and he would give them this sentiment—"Success to our next merry meeting." It was arranged that the next meeting should be held in Birmingham in September, and he had no doubt that they would be received in as hospitable a manner as they were in Yorkshire, Nottinghamshire, and in Northumberland.

The PRESIDENT proposed "Her Majesty's Inspectors of Mines," to whom, he said, the mining engineers were indebted for much valuable assistance. This toast having been honoured,

Mr. WM. COCHRANE said they would all join very heartily in congratulating themselves, not only on having their Chairman as President of this Institution, but on having as their Chairman a friend and a venerable gentleman who had arrived at an age allotted to very few It was an honour to have such a friend and fellow-worker, They could not separate without thanking their President for his valuable services, and congratulating him that his health and strength had enabled him to go through the labours of that day, and that at the end of the day they should find him so happy and contented. Might he be spared many years yet to be an example to them, and to remind them to be in their lives what he had been in his; and might they be able to show anything like the same health, strength, and vigour when they arrived at his age.

The PRESIDENT said he could only say how very much obliged he was to Mr. Cochrane for the sentiments he had expressed, and he hoped the morrow's proceedings would end as agreeably as the present day's had done. He might say this that if a person wanted to live long he must work hard when young, take it rather more quietly when he attained middle age, and when he came to fourscore years he must take it very easily. And during all that time he must eat and drink frugally, not living every day on great delicacies such as they had enjoyed that day, but having something which was quite plain and common. If that was done the digestion would not suffer, and there would be no occasion to take dinner pills after dinner, and the liver and other things would not get out of order. He would not detain them longer; he hoped he would be spared until the September meeting and many meetings after that, for he felt quite well and might almost say young; the only deficiency he felt was in his knees, which were growing very weak and feeble. If any mechanical engineer could supply him with a new pair he would be glad to have them.

The proceedings then terminated.

FEDERATED INSTITUTION OF MINING ENGINEERS.

GENERAL MEETING,

HELD IN THE ROOMS OF THE INSTITUTION OF CIVIL ENGINEERS, 25, GREAT GEORGE STREET, WESTMINSTER, MAY 29TH, 1891.

MR. T. W. EMBLETON, PRESIDENT, IN THE CHAIR.

Mr. YATES read the following paper on "An Electrical Safety Apparatus for Cages":—

AN ELECTRICAL SAFETY APPARATUS FOR CAGES.

By John Yates.

Although great advances have been made in recent years in nearly every branch of mine engineering, we are no better off to-day for a reliable safety cage than we were twenty years ago. Engineers have either been unable to devise a good safety apparatus, or they have not given that attention to the matter which it deserves.

That it does deserve attention cannot be doubted in the face of the statistics contained in the reports of H.M. Inspectors of Mines. According to these reports, there were between the years 1880-1890 no less than 45 fatal accidents, resulting in 87 deaths, caused by the breaking of ropes and chains in shafts.

Forty-five fatal accidents in ten years is certainly a very serious state of things, but although this is a large number there is cause for sincere congratulation, that out of the millions of miners whose lives have at one time or other during the last ten years been hanging, so to speak, by a thread, so few have lost their lives by the breaking of that thread. The fact remains, however, that 87 lives have been lost through causes which are entirely preventible, for had the cages been provided with efficient safety appliances every life might have been saved. These figures should convince the most sceptical of the desirability of safety cages.

Engineers are well aware that many of these so-called safety cages have been brought forward from time to time, but have not found very much favour in this country, although on the Continent they are very generally applied.

Though their construction is faulty, they have been the means of saving numerous lives, and have perfectly justified their adoption and verified their claim to the name of safety cage.

The writer considers that their construction is faulty, and this is borne out by the evidence given before the late Commission appointed to investigate Accidents in Mines. In the reports issued by this Commission it will be found that many of the managers who had applied safety cages spoke very favourably of them, but that others raised objections to them, on the ground that they were apt, in quick winding, to come into action when not required, and that they did not invariably act when they should do. It was because of the objections thus raised that the Commissioners, although evidently desirous of advising the general adoption of safety cages, were compelled to admit that, after examining nearly all the safety cages introduced up to that date, "they were unable to come to the conclusion that any one of them was a trustworthy safeguard against accident."

The late Sir Warington Smyth, the President of the Commission, in referring to the safety cages which had so far been introduced, said that "they were apt in quick winding, when the rope surged or slacked, to come into action when not

required, and that this, along with the common dislike of trusting to a spring for setting it in action, militated against their general adoption by the coal trade."

That the safety cages which have so far been put before the public have not been an unqualified success is due to the fact that they rely upon springs to set the apparatus in action, and that something more than the mere breaking of the rope is requisite to let these springs act. The fracture of the rope is not in itself sufficient to actuate the apparatus—many of them require a release of tension or compression, whilst others depend upon the cage attaining a certain velocity.

Experience has shown that an apparatus which acts indirectly, through the medium of a spring or otherwise, is not to be relied upon.

What is wanted is an apparatus which will require nothing more to bring it into action than the breaking of the rope, and which will be entirely independent of everything but this.

For some time past the writer has been at work on this matter, and the result of his labour has been the invention of an apparatus which appears to promise perfect safety in case of breakage of the rope.

Before describing the invention, the conditions which a safety apparatus should fulfil may be stated as follow :—

1.—It should never fail to act when required.

2.—It ought never to come into play except when the rope breaks.

3.—It should allow of being tested.

4.—It must be simple in construction and require little attention.

5.—It should in no way interfere with the ordinary work.

This is the standard to be attained by a good safety cage, and the manner in which this standard may be attained is to use the hauling rope as the means for conveying a current of electricity to four electro-magnets on the cage, each of the magnets sustaining a gripping cam. On the fracture of the rope and the breaking of the current, the cams would drop into play against the guides.

This is a general outline of the apparatus, the details of which will now be described.

The rope is, to all intents and purposes, the ordinary hauling rope, except that it has two insulated copper wires in the hemp core. It differs from the ordinary winding rope in no other respect, and thus, so far as winding is concerned, engineers have what is practically the ordinary rope. That such a rope can be made, and will transmit a current of electricity in a satisfactory manner, is beyond doubt, for a similar rope is now in use with the Armstrong electrical signalling apparatus—an apparatus for signalling between the engine house and the cage whilst in motion. This signalling apparatus has been applied at many of the collieries in the Durham district, and has been in daily work for some years. It has given every satisfaction.

Messrs. Haggie, of Sunderland, who have the making of this apparatus, have kindly presented me with a piece of the rope used, and it is here for inspection.

A better test than what the rope has been subjected to could not be wished for, and the manner in which it has stood the trial of daily work for years should be sufficient to convince anyone that not the slightest difficulty is to be apprehended from the rope.

The copper wires of the rope are connected at the cage end to the electro-magnets (Figs. 3 and 4, Plate XXXIII.), and at the drum end to two insulated copper rings on the drum axle, these rings being connected to the battery, as shown in Figs. 1 and 2, Plate XXXII.

The current goes down one wire and up the other, and is generated by a battery of a few cells, such as the Daniell, these giving a constant current, and requiring no attention except the adding of a few crystals of copper sulphate ($CuSO_4$, $5H_2O$) at intervals. With a battery of this description a perfectly continuous current can be obtained without the slightest difficulty and without the least trouble.

The electro-magnets are of the horse-shoe form, these being the most suitable, such electro-magnets can be made to sustain a weight of 200 pounds per square inch of section. It will thus be seen that a comparatively small magnet may be made to support a great weight or pull, and electro-magnets have been made to sustain over two tons. Whilst speaking of the lifting power of magnets, it may be of interest to mention a rather novel use to which they have lately been put. They have recently been attached to cranes, and used for lifting masses of iron, instead of the ordinary lifting tackle.

The arrangement for gripping the guides consists of four levers (Figs. 3 and 4, Plate XXXIII.), each lever working independently of the others. One end of these levers is so shaped as to form the gripping cam, and the other end is heavily weighted, also having a spiral spring attached, as shown. The weight and the spring tend to pull the long arm of the lever down, and thus throw the cam into contact with the guide. The electro-magnets are placed directly over these weights and support them, thus keeping the cams out of action.

Here attention must be called to the simplicity of this gripping apparatus, consisting as it does of only one lever. Instead of having a cumbrous, complicated arrangement of levers, bell cranks and springs, together with, in many instances, a special suspending frame—instead of all this there is a single lever, which cannot possibly get out of order, or jam.

Again, in some of the safety cages at present in use, there is a connection between the rope and the gripping levers; hence, when the rope breaks, the action of the apparatus is impeded, and might actually be prevented, by that part of the rope trailing behind the cage.

In the apparatus proposed, however, it will be seen that the action of the levers is free and entirely unimpeded—there is nothing to interfere with their action.

Another very important advantage of this arrangement, and one to which especial attention is directed, is, that there are in reality four distinct sets of safety apparatus, instead of the usual one, for as before remarked, each of the levers is complete

in itself. Thus, assuming for the moment that any one or two of the levers failed to come into action, their failure would in no way affect the other levers, and these coming into contact with the guides, would, in all probability, also cause the others to act. When there is a rigid connexion between the levers, things are entirely different—there is only one apparatus, and the jamming of any part of the apparatus keeps the whole out of action.

The advantage of the independent action of the levers will be perceived; and seeing that there are four levers, each weighted, and under the action of a spring, it would appear impossible for the apparatus not to act on the breaking of the rope. Seeing that a continuous current can be obtained, it would appear equally impossible for the apparatus to come into action when not required, for so long as the rope is intact and the current passes, the levers cannot come into action. The spurting of the engine, the slacking and surging of the rope, and the landing at the keeps are without effect on the apparatus.

Another good characteristic it possesses is that of instantaneous action—the cams would grip as soon as the rope broke.

If the fracture occurred whilst ascending, the apparatus would be in action before the cage came to rest, and would entirely prevent any downward motion. If the accident occurred whilst descending, then the apparatus would grip before any further velocity had been attained.

The apparatus could be tested at any time by breaking the circuit, thus allowing the levers to grip.

A safety apparatus should be periodically tested. With many kinds of safety cages this is the only means of ascertaining whether they are in working order, but the electrical safety apparatus which is proposed would itself indicate when it was out of order.

The description of the apparatus may be completed by saying that the other diagrams (Figs. 5, 6, 7, 8, and 9, Plate XXXIV.) indicate different methods of gripping the guides. In the apparatus for rope guides it is proposed to have projections on the inside of the conical wedges, as shown, these projections being arranged in a spiral manner. When the wedges are forced up by the levers, the projections would catch in the strands of the rope, and the wedges would be carried up still farther, firmly gripping the rope and stopping the cage.

The apparatus is so simple in construction that the average miner would, after five minutes' inspection, thoroughly understand the working of it, and it would only require two or three minutes a day spending on it to keep it in thorough working order.

In conclusion, the cost of applying and maintaining such an apparatus would be trifling; and attention is called to the fact that the apparatus combines in itself all the qualities that a safety cage should possess, and it would, therefore, appear that miners have at last within their reach a perfectly reliable safety apparatus, which will make those terrible accidents caused by the breakage of ropes a thing of the past.

Mr. WM. COCHRANE (Newcastle-upon-Tyne) said he was rather amazed at the statement in the first paragraph of the paper that "we are no better off to-day for a reliable safety cage than we were twenty years ago." Had Mr. Yates's apparatus yet been tried, or was it only in his mind?

Mr. YATES explained that his invention had not been applied at any colliery, and the paragraph in the paper referred to the use of the Armstrong signalling rope; he could, if desired, give the names of the collieries where the Armstrong rope was in use.

Mr. W. C. BLACKETT (Durham) said the arrangement described had the merit of ingenuity, but he failed to see in what respect it was any better, if so good, as many that had gone before. To take the author's own conditions: "No. 2. It ought never come into play except when the rope breaks." Anybody who had examined the model and read the paper would see that the apparatus came into action if the battery failed, and those who had had experience with batteries of the most simple kind knew very well that nothing was more liable to go wrong than a battery. "No. 4. It must be simple in construction, and require little attention." He did not dispute the simplicity of its construction it seemed to have a large share of simplicity; but it would require a great deal of the closest attention. He thought no man could say when a battery was about to go wrong, and no amount of attention would prevent it going wrong, although by attention a battery would, no doubt, be kept in better order than if it were neglected. If the apparatus came into action in the middle of quick winding, or even in the ordinary winding when men were being taken up or down the pit, it would be very awkward, and more especially if the guides gave way. "No. 5. It should in no way interfere with the ordinary work." But if the battery went wrong without doing any other damage than stopping the cage, or even when the cage was standing, the pit would have to wait for drawing coal until the engineman discovered what was wrong and put it right, and it sometimes took a long time to discover what particular cell went wrong. In that way it would interfere largely with the drawing of coals, and it would probably have to be tied up to prevent it coming into action until the battery was put right.

Mr. A. L. STEAVENSON (Durham) thought that an apparatus of this kind was best described by having one fitted up in an ante-room and its working explained. The writer observed in the paper that "miners have at last within their reach a perfectly reliable safety apparatus," but his (Mr. Steavenson's) experience of everything which required electricity or a knowledge of electricity to use it was the most uncertain of all appliances. He happened to have a telegraph in his house, and electric signals at his mines, and there was something wrong with them about once a fortnight, and if they were to have something wrong with a safety apparatus once a fortnight where would they be? For thirty-six years he had used the Calow safety apparatus, which did not come into action until it became a falling body by the rope breaking. It seemed to him that the Calow cage was more reliable than any electrical contrivance, and he thought where they had a deep quick running shaft it was better

To illustrate Mr. John Yates' paper on "An Electrical Safety Apparatus for Cages."

FIG. 1.

ELEVATION

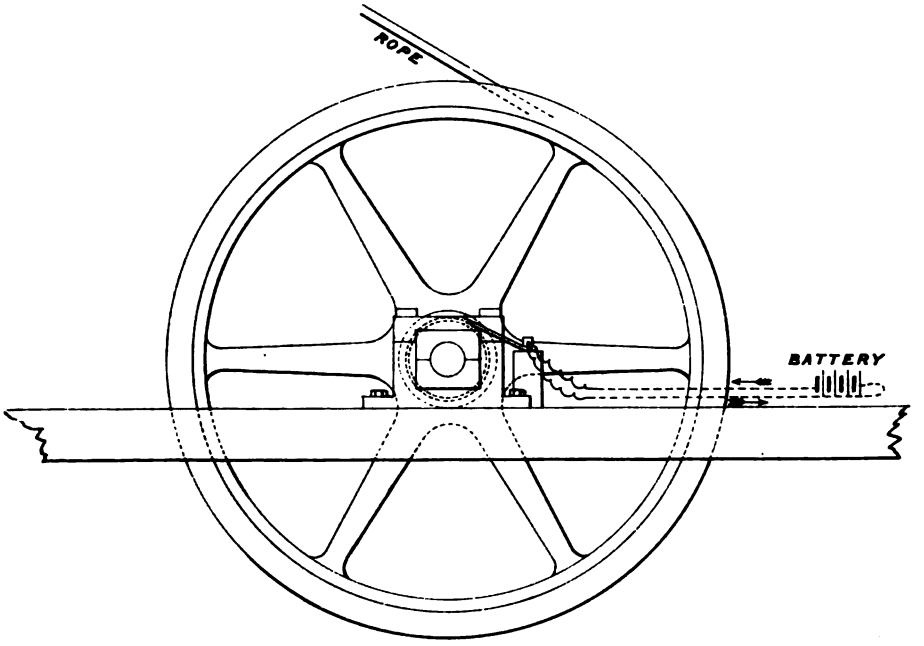
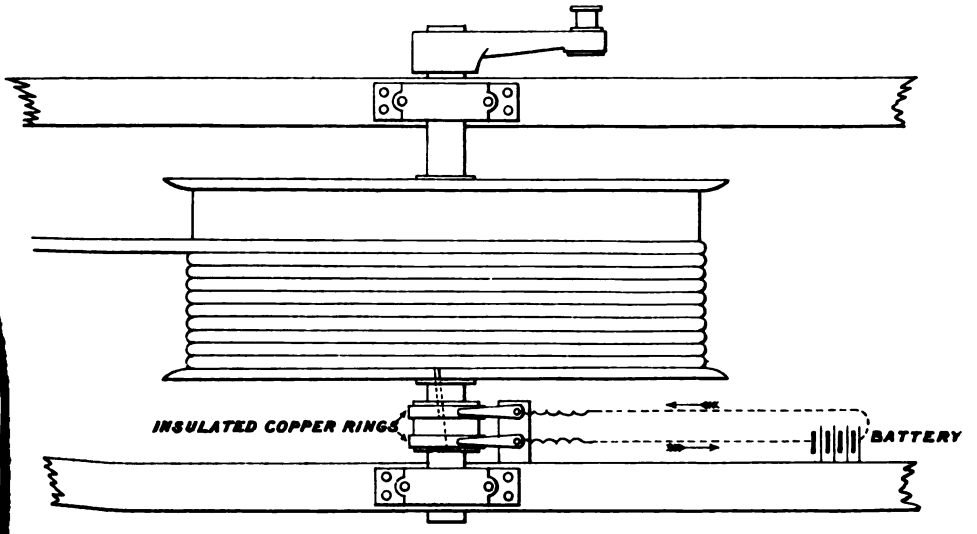


FIG. 2.

PLAN.



And.w Reid Sons & Co. Lith. Newcastle

Illustrate Mr. John Yates' paper on "An Electrical Safety Apparatus for Cages."

FIG. 3.

END ELEVATION OF CAGE

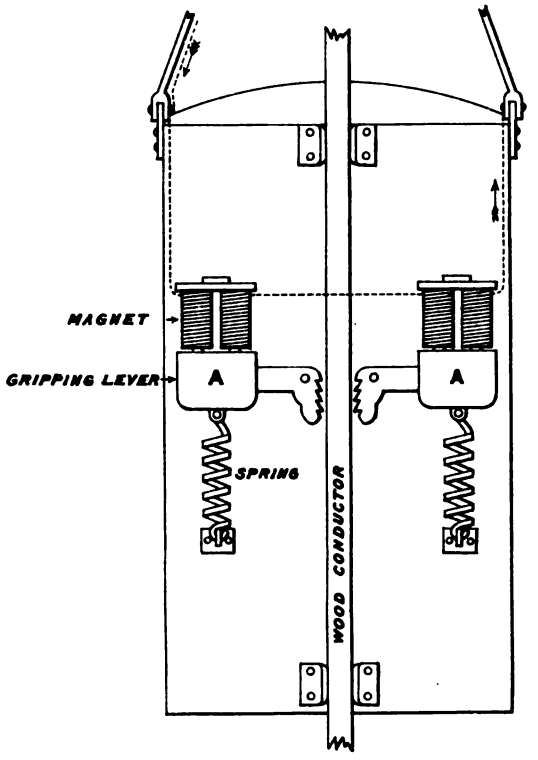
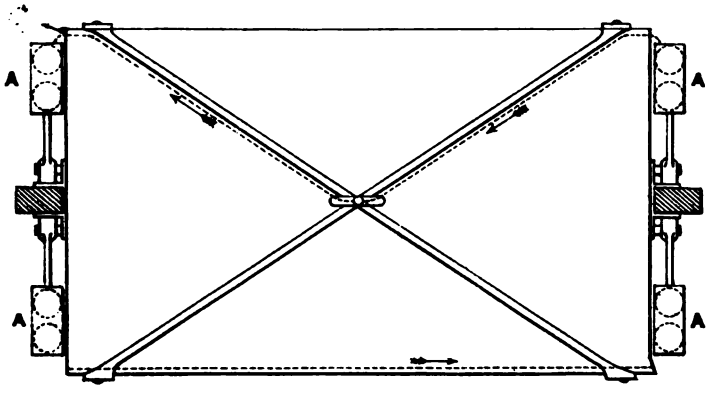


FIG. 4.

PLAN OF CAGE



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To illustrate Mr. John Yates' paper on "An Electrical Safety Apparatus for Cages."

FIG. 5.

ELEVATION.

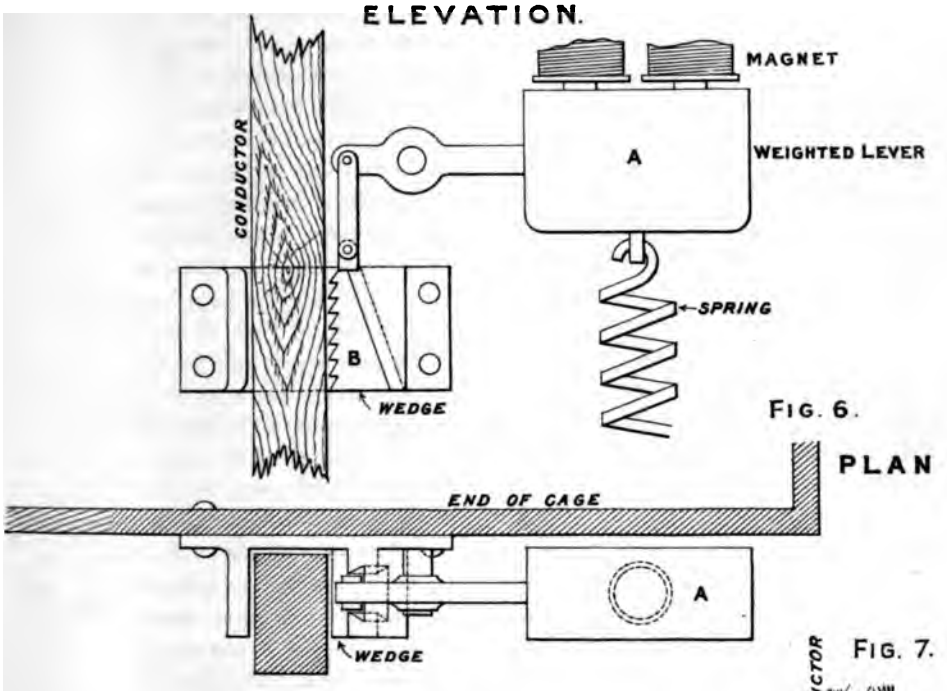


FIG. 6.

PLAN

FIG. 7.

SECTION of Wedges, showing projections which are arranged spirally

FIG. 8.

ELEVATION.

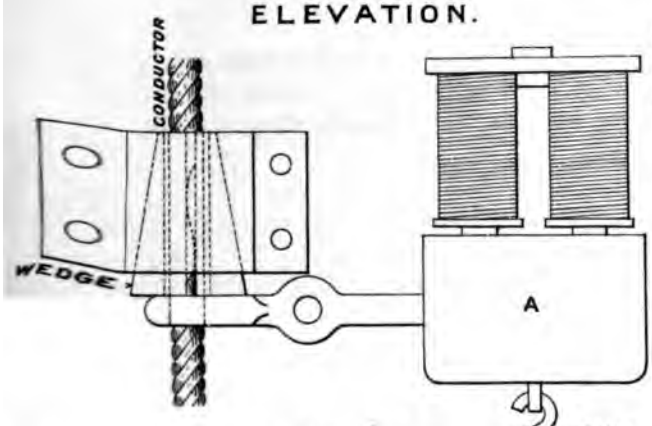
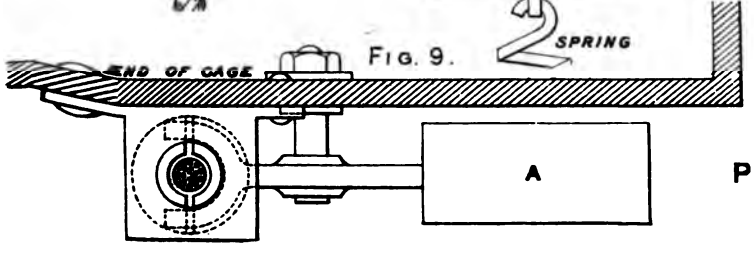


FIG. 9.



PLAN.

A. J. Re, Lithos, Newcastle

to withdraw these appliances and trust to good ropes well inspected several times a day. He was sure many of H.M.'s Inspectors of Mines would, with their extensive experience, support him in his statement.

Mr. YATES said that for a given amount of work the length of time that a battery would run without attention depends chiefly upon the capacity of the cells, and of course they could have any size they pleased, so that if it was desired to run the battery for three or four days without attention all that was necessary was to have the cells sufficiently large. Besides the Daniell battery there were many others that gave a constant current; for instance, the Bunsen, the bichromate, and a modified form of the Leclanché, the last of which will run without attention for two or three weeks. As regards not knowing when the battery would go wrong it was the easiest thing in the world to attach an indicator, which would at once show by inspection how the current was. The reason electrical signals, etc., sometimes failed was that a Leclanché battery was used which, being intermittent, very often failed; but there were other batteries in the market which would give a constant current without the least trouble. With reference to the apparatus coming into action by "jogging," they would of course allow for a margin of safety. Nobody would think of using a fifty-pound magnet to lift at sixty pounds weight.

The PRESIDENT said it was a useful apparatus to bring before the members, but its effect had not yet been practically tested. The author said it had been brought before the public for the first time to-day, and therefore they could not judge of its merits until a practical trial took place. He therefore proposed that a vote of thanks be given to Mr. Yates for his interesting paper.

The proposal was received with acclamation.

The following report on the effect of the fumes of roburite and tonite was then read—the chemical portion of the report by Dr. P. Phillips Bedson, and the remainder by the Secretary:—

AN INVESTIGATION AS TO WHETHER THE FUMES PRODUCED FROM THE USE OF ROBURITE AND TONITE IN COAL MINES ARE INJURIOUS TO HEALTH.

REPORT OF THE COMMITTEE OF THE DURHAM COAL OWNERS' ASSOCIATION AND OF THE DURHAM MINERS' ASSOCIATION.

Complaints having been made by the workmen at various collieries that the fumes produced by roburite and tonite were injurious to their health, the matter received the attention of a Committee of the Durham Coal Owners' Association, who suggested that the question should be investigated by the North of England Institute of Mining and Mechanical Engineers.

The matter was accordingly brought before the Explosives Committee of that Institute, but that body considered that it would not be justified in interfering in any way in a dispute between employers and employed as to the use of any particular explosive, or in applying the funds of the Institute for the purpose. The Committee, however, stated that individual members would be glad to serve on any Committee which might be appointed by the Coal Owners' Association.

A general meeting of the Durham Coal Owners' Association was held on September 16th, 1889, to further consider the question, when the following resolution was agreed to :—

> "That a Committee be appointed by the Durham Coal Owners' Association, consisting of Messrs. A. L. Steavenson, W. Lishman, George May, M. W. Parrington, W. Armstrong, Jun., F. S. Panton, W. O. Wood, and T. Lishman, with Messrs. Bell and Willis (H.M. Inspectors of Mines), W. Crawford, J. Forman, John Wilson, W. H. Patterson, and four workmen, to investigate the question as to whether the fumes produced from the use of roburite and tonite in coal mines are injurious to health, with power to call in experts."

This proposal was submitted to the Miners' Association, and agreed to by them, and the Committee was formed. Mr. Thomas Bell, H.M. Inspector of Mines, was appointed Chairman of the Committee, Professor P. P. Bedson and Drs. Drummond and Hume professional advisers, and Mr. M. Walton Brown, engineer.

Arrangements were made for experiments with the explosives which were the subject of the enquiry, the first series being made at Elemore Colliery in the presence

of the Committee. In consequence, however, of the large number present interfering somewhat with the experiments, it was agreed that in future experiments the Committee should first visit and inspect the working places where the shots were to be fired, and satisfy themselves that these were in their ordinary working state, and that the actual firing of the shots, the collection of the fumes, etc., should take place only in the presence of a Sub-committee. This method was adopted in the other experiments mentioned in the reports.

Experiments were made as follow :—

Name of Colliery.	Date of Experiments.	Nature of Explosive used.
1.—Elemore	October 24, 1889 ...	Roburite.
2.—South Hetton ...	November 22, 1889 ...	Tonite.
3.—Elemore	February 5, 1890 ...	Roburite.
4.—South Hetton ...	April 1, 1890	Tonite.
5.—Haswell	May 14, 1890... ...	Gunpowder.
6.—South Hetton ...	July 22, 1890... ...	Roburite and gunpowder.
7.—Elemore	March 5, 1891 ...	Roburite.

At the final meeting of the Committee on the 6th of April, 1891, the reports of the professional advisers were submitted, and

On the motion of Mr. W. O. Wood,

Seconded by Mr. W. H. Patterson,

It was unanimously resolved that the reports be received and adopted, and that they be printed and circulated.

A very hearty vote of thanks was also given to the professional gentlemen for the great care and attention they had given to the enquiry, and for their very valuable reports.

At the suggestion of Mr. Parrington it was agreed that permission should be given to the Mining Institute to publish the reports in their Transactions. A vote of thanks to the Chairman terminated the proceedings.

REPORT ON THE CHEMICAL EXAMINATION OF THE FUMES.

By P. Phillips Bedson, D.Sc. (Lond.), F.C.S.,
Professor of Chemistry at the Durham College of Science.

Introduction.

In accordance with the decision of the Explosives Committee of the Durham Coal Owners' and Miners' Associations, the experiments made with a view of determining whether the fumes produced by the use of the explosives roburite, tonite. and gunpowder are injurious to health, were conducted in the mines under ordinary working conditions. The arrangements and observations made at the several mines may be considered under three headings :—

I.—*Observations, etc., made at the Intake.*

A district having been selected for the shot firing, an assistant was stationed in each case at a given point at which samples of air supplying the district could be collected during the firing of the shots, these collections being made as follows:—An average sample of the air travelling past this point during the course of an hour was collected, by suspending from the roof in the middle of the roadway a zinc aspirator (Fig. 1), of about 600 cubic inches capacity, provided with openings above and below which were closed by taps. The aspirator having been completely filled with water, at a stated time, the taps were opened and the water was allowed to flow out at such a rate that the aspirator would empty itself in about an hour, and the water be replaced by the air drawn in through the upper opening. The vessel was then tightly sealed.

A quarter of an hour after starting the aspirator a smaller sample of air was collected by drawing the air through a glass vessel (a pipette), which was then sealed up; and in about half an hour from the commencement a bottle, of about 30 cubic inches capacity, was filled with the air, in which the proportion of carbonic acid was determined.

In addition to these operations, the assistant at this point made observations as to the temperature, the volume of the air current, and also the barometric pressure of the air.

II.—*Observations made at the Return.*

A position having been selected so as to intercept the air immediately after its passage through the district in which the shots were fired, a second assistant was stationed at this place, and provided with apparatus, etc., to make a similar series of collections and observations to those made at the intake. The collecting of the samples of air being timed as far as possible in such a way that the air collected should be representative of the vitiation resulting from the operations conducted in the district during the time of shot firing.

III.—*Observations made after the Firing of Shots.*

In collecting samples of the fumes produced by the firing of shots I at first attempted to do this by placing, some distance from the several working places, zinc aspirators similar to those used in the intake and return. These aspirators (Fig. 1) having been previously filled with water were suspended from the roof in the middle of the roadway. Attached to the upper aperture was a tube plugged with glass wool, by which the solid portion of the fume was retained as the air was drawn through it into the aspirator. After the shot had been fired, the aspirator having been fixed in the air-way at a short and suitable distance from the working place, on the approach of the fumes carried along by the air current, the lower tap of the aspirator was opened and the water allowed to flow out rapidly, thus drawing into the aspirator a sample of air and fumes admixed with one another In addition to

these larger samples of air, others were collected in smaller vessels by rushing into the place immediately after the firing of a shot, and filling them by drawing the fumes through them. This method of collecting the fumes from the shots was abandoned after the first trial, as it was found impracticable to get sufficiently near to the working place, and further, with the air travelling at a high rate the samples collected were too largely diluted with air to be of much value. The fears entertained when working in the mine were confirmed by the results of examination to which the various samples were submitted in the laboratory.

Figure 1.

The method I employed in all subsequent experiments was one which enabled me to get to the face immediately after the firing of the shot, and to make a collection of the fumes hanging about the face and in the fissures of the coal. For the collection of large samples of air several brass cylinders (Fig. 2) were provided some 24 inches in length and 6 inches in diameter, having a capacity of about 678 cubic inches. At one end of the brass cylinders were two apertures, in which were fixed two narrow brass tubes, firmly attached to which were pieces of thick walled india-rubber tubing, the openings of the same being closed by glass plugs. In the first instance the cylinders were exhausted by means of an air-pump and then tightly closed. Before using these I satisfied myself by careful testing that in them a vacuum could be maintained for several days. Then, the day before visiting a mine the cylinders were thoroughly exhausted and carefully and tightly closed; and prior to descending the pit, the cylinders were on every occasion tested by connecting them with a mercury pressure gauge, and in every case they were found in a perfectly satisfactory condition, the gauge indicating that the vacuum had been maintained. Provided with these exhausted cylinders it became a comparatively simple matter to collect a sample of the fumes produced by a shot which was done in the following manner:—Having secured a sheltered position, as near to the working place as possible, I awaited the report produced by the firing of the shot, after which I immediately rushed to the face of the coal, carrying with me one of the vacuous cylinders, which was then only closed by a stout clamp on one of the pieces of india-rubber tubing. By loosening the clamp the cylinder was opened and

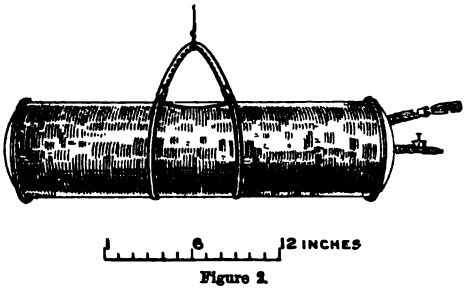


Figure 2.

quickly filled with the fumes rushing into the exhausted vessel. In order to separate any solid matter from the gaseous bodies, a piece of glass tubing plugged with glass wool was fixed to the india-rubber tubing, so that the air must, in passing into the cylinder, be drawn through the wool and thus the solid matter filtered from the gaseous matter. The cylinder thus filled was then tightly stoppered and transported to bank. In addition to the collection of these larger samples, smaller samples were collected in a similar manner in glass pipettes.

Whilst this mode of collection enabled me to reach the face almost immediately after the shots were fired, and thus to obtain samples of the fumes hanging about the coal, and consequently representing them at their worst, the extent of the dilution of the fumes by the air would be influenced by the following conditions:—(1) The distance of the sheltered position from the face, and consequently the time elapsing between the explosion and reaching the face, (2) the rate of the air current at the time of collection. Still, despite the influence of these conditions, the results obtained show that I have been able to collect specimens of the gaseous products and to measure the amount of these substances produced by the explosives. The proportion of the fumes to air in such samples must naturally depend upon the influence of one, or other, or of all the conditions named, and may consequently vary considerably in different collections. In illustration of this I would mention the results obtained with roburite at South Hetton, on July 22nd, 1890. On this occasion I made two collections at the face immediately after the firing of the second shot at each working place. The air collected at the first place contained 0·98 volume per cent. of carbonic acid gas and 0·24 volume per cent. of carbon monoxide; whilst that collected at the second place contained 0·114 volume per cent. of carbonic acid gas and 0·014 volume per cent. of carbon monoxide.

On returning to bank, the several vessels containing the samples of air were all carefully sealed by dipping the stoppers in molten paraffin wax, and after packing were taken to my laboratory for examination.

The samples of air collected in the intake and return for the purpose of estimating the amount of carbonic acid gas were in every case examined on arrival at bank.

Examination of the Gases Collected in the Mines.

From the above it will be seen that both in the intake and the return three different collections were made—one served for the estimation of the amount of carbonic acid gas in the air, the second for the determination of the proportion of oxygen, and the third, viz., that collected in the zinc aspirators, was submitted to careful examination to ascertain whether other than the ordinary constituents of air were present. Similarly, the collections made in the brass cylinders after the firing of the shots were utilized to ascertain the proportions of oxygen and nitrogen, and of carbonic acid gas, and were also examined for other gaseous bodies, the smaller collections being simply used to ascertain the proportion of oxygen and carbonic acid gas to nitrogen.

From the nature of the explosives used it was to be expected that carbon monoxide might be a product of their explosion, the collections were not only examined for this, but I also had suspended in the return air a box containing a mouse; for it is well known that this gas exerts its poisonous influence through the blood. The gas is, in fact, absorbed by the blood; and, further, the blood of an animal which has been breathing air containing this gas, when examined by the spectroscope, can be distinguished from ordinary blood. The mouse, after being in the air-way of the return for a given time, was drowned, and on arrival at bank its blood examined with the spectroscope.

Results of the Examination of the Collections made in the Mines.

Roburite.

This explosive consists of a mixture of either dinitrobenzene or chloro-dinitrobenzene and ammonium nitrate; the roburite used in these experiments was a mixture of chloro-dinitrobenzene and ammonium nitrate. The fumes produced by this explosive were made the subject of three different series of experiments. The first two were conducted at Elemore, and the third at South Hetton.

The first visit to Elemore was made on October 24th, 1889, on which occasion the members of the Committee were present to witness the shot firing. The roburite was fired by Bickford's fuse. The shot firing commenced at 3·30 p.m., and from that time up to 5·20 there were in all some 23 shots fired—a total weight of 88·84 ounces, or 5·5 lbs. of roburite.

The samples in the intake were collected between 3·32 and 4·34 p.m., and at the return between 3·35 and 5·3, the larger aspirator running for 1 hour and 28 minutes.

During the shot firing four aspirators were filled from different shots, a sample collected for carbonic acid, and the fumes from four shots were tested for carbon monoxide with a dilute solution of blood. Two vessels were also filled with fumes for subsequent determination of the proportion of oxygen to nitrogen. The examination of the several samples collected failed to reveal the existence of any deleterious gas. The contents of the several aspirators were specially examined for carbon monoxide, nitric oxide, and hydrochloric acid, but with negative results. Further, the blood of a mouse which was suspended in the return air during the whole period of shot firing gave no indication of the presence of carbon monoxide.

The second visit to Elemore was made on February 5th, 1890, and as the experiments were conducted in the same district as before, the shot firing was witnessed by members of the Sub-committee, the district having been first inspected by the other members of the Committee. The shot firing began at 2·15 p.m. and finished at 4·15. In the intake the operations were commenced at 2·5 and completed at 3·5, whilst at the return the collections were begun at 2·20 and completed at 3·45.

During the firing of the shots samples of the fumes from three different shots were collected in the exhausted brass cylinders in the manner mentioned above, and

four smaller samples were collected in pipettes similarly exhausted. On this occasion 23 shots were fired, and I personally witnessed the firing of 17 of them. The weight of roburite used would be 75·14 ounces, or 4·7 lbs.

The results of the analysis of the several samples of air collected in the intake showed that the district was supplied with air of average composition, whilst that in the return naturally contained more carbonic acid and less oxygen. On this occasion two aspirators were filled in the return, and the air of these showed, when carefully examined in the laboratory, the presence of traces of carbon monoxide. The method I employed for the detection of carbon monoxide was one which, after many trials of other methods, I had found to be the most delicate and reliable. It consisted in drawing the air slowly through a series of tubes containing a solution of palladium chloride, which is decomposed by carbon monoxide, metallic palladium being precipitated and the carbon monoxide converted into carbonic acid gas. The amount of palladium precipitated, and the proportion of carbonic acid gas formed enable me to estimate the amount of carbon monoxide present in a measured volume of air. The use of this method enabled me to detect the presence of minute proportions of carbon monoxide, and by using several litres of air, to estimate as little as one volume of carbon monoxide in 10,000 volumes of air. Before applying this method to the examination of samples collected in the mines, I had previously, by experiments with mixtures containing known amounts of carbon monoxide, satisfied myself of its utility.

Each of the collections in the brass cylinders were found when thus examined to contain amounts of carbon monoxide, varying from 4·2 to 1·9 volumes per 10,000 volumes of air, or 0·042 and 0·019 per cent.

The third series of experiments were conducted at South Hetton on July 22nd, 1890. On this occasion the mode of conducting the experiments was modified so as to admit both of the use of gunpowder and roburite. A district having been selected, three places were prepared in which gunpowder was fired, and three others in which roburite was fired. Samples of the intake air were taken as before, and an observer stationed at a point in the return air-way made collections during the firing of the gunpowder, and then moved to a second station in the return air-way to collect samples of the air during the firing of the six roburite cartridges.

On this day six shots of 6 ounces each were fired, making a total of 36 ounces or 2·25 lbs. of roburite.

The air collected in the return during the firing of the roburite gave no indication of the presence of carbon monoxide, whilst this gas was found in both of the samples of fumes collected immediately after the firing of shots, by going to the face of the coal and holding the nozzles of the cylinders in the fumes. In the first case the fumes appeared to clear away but slowly and hang about the fallen coal, and I held the nozzle of the cylinder amongst these, so that I was able to collect air representative of these fumes at their worst. The subsequent examination showed the existence of

about 0·24 volume per cent. of carbon monoxide or 24 volumes per 10,000 in this sample. In the second case the proportion of carbon monoxide found in the fumes was only 0·014 volume per cent. or 1·4 volumes per 10,000. Results such as these show that the air current acts at once in clearing away the fumes after the shot has been fired, and in a short time the fumes are carried away and so diluted by the air current that, as in the case of the experiments on this occasion, carbon monoxide could not be detected in the return air.

Tonite.

This explosive consists of equal parts of gun-cotton and barium nitrate, which are intimately mixed and compressed into cylindrical cartridges, with a cylindrical hole at one end for the insertion of the detonator. The cartridges are encased in paper made waterproof by dipping into paraffin wax. The explosive was investigated at South Hetton on two occasions, the first visit being made on November 22nd, 1889, and the second on April 1st, 1890. In using this explosive the cartridge is surrounded by a so-called flame-extinguishing mixture, which is packed round the cartridge in a brown paper cylindrical bag. The detonator used was fired by means of Bickford fuse, as in the case of roburite.

On the occasion of the first visit, the district having been inspected by members of the Committee, the shot firing was performed in the presence of the Sub-committee. The general arrangements for collecting the samples were similar to those followed at the second series of experiments with roburite. On this occasion 19 shots were fired, weighing 107 ounces, or 6·69 lbs. The shot firing commenced at 2·15 p.m., and was completed at 3·45, the intake collections commenced at 2·33, and at the return operations began at 2·45. During the firing of the shots three samples of fumes were collected in the brass cylinders, and four smaller samples in exhausted pipettes.

The blood of a mouse which was exposed to the return air gave, on examination with the spectroscope, an indication of the presence of carbon monoxide, but this was practically the only indication obtained on this day of the presence of any injurious gas in the fumes from tonite. The samples of air collected in the return and in the intake, as also those collected in the cylinders, when passed through tubes containing heated palladium asbestos, yielded different proportions of carbonic acid showing the presence of some combustible gas, possibly carbon monoxide, or more probably marsh gas and carbon monoxide. The amount of this combustible gas was very small in the air of the intake, and though in all cases small, was greater in the return air and also in that collected in the cylinders. This method of examination did not, however, allow of any dogmatic statement as to the exact nature of the combustible gas.

On the occasion of the second series of experiments with this explosive, viz., on April 1st, 1890, the shot firing was conducted in the presence of the Sub-committee only. The several collections were made in the intake and return as on the previous visit. There were 13 shots fired, representing 71 ounces of tonite, or 4·43 lbs.; and

during the shot firing I collected three samples of the fumes in three cylinders, and also made four different collections in exhausted pipettes.

The method of examining the samples of air in the aspirators and in the cylinders for carbon monoxide consisted in passing the air slowly through tubes containing solutions of palladium chloride, by which, as I have already mentioned, the carbon monoxide is converted into carbonic acid gas and metallic palladium precipitated. The results obtained showed the absence of this gas in the intake air, its presence in traces in the air of the return, and in amounts varying from 2·4 to 5·9 volumes per 10,000 volumes of air or 0·024 to 0·059 per cent. in the fumes collected in the exhausted brass cylinders.

Gunpowder.

On March 13th, 1890, the Committee visited Tursdale with the object of testing this explosive, but owing to the condition of the district selected it was deemed desirable not to fire shots.

On May 14th, 1890, the Committee visited Haswell, in which mine gunpowder is ordinarily in use, and after the district had been inspected by the members of the Committee, the shot firing was conducted in the presence of the Sub-committee. The observations in the intake were commenced at 1·55, and completed at 3·10 p.m., and at the return commenced at 1·50, and completed at 3·20 p.m. During the shot firing 24 shots were fired, representing 110 ounces or 6·88 lbs. of gunpowder. Samples of the fumes were collected in three exhausted cylinders, and three pipettes were also filled.

With respect to the fumes from gunpowder, it is to be remarked that their distinctive feature is to be found in their marked visibility, as compared with those from roburite and tonite, and also in the distinct evidence of the presence of sulphuretted hydrogen, as not only indicated by the characteristic odour, but also by the fact that silver—both money and jewellery—was discoloured by these fumes. The results of the examination of the several samples collected on this occasion by methods similar to those used and already described, showed the presence of traces of carbon monoxide in the return air, and of traces of this same gas in the samples collected in the brass cylinders at the firing of the shots. It was noticeable that, owing to the volume of the air current, the fumes were more rapidly dissipated than at Elemore or South Hetton, and, therefore, the several collections made on this occasion would be more diluted than similar collections made at Elemore and South Hetton.

In order to test this explosive under similar conditions to those under which experiments were made with roburite and tonite, a set of experiments was made at South Hetton on July 22nd, 1890, on which occasion roburite was also experimented upon. On this day collections were made at the intake as in previous experiments, and at three different places shots were fired with gunpowder, and during that time collections were made at a point at which the air was intercepted after passing the places at which the shots had been fired. Six places in all were

prepared, and gunpowder was fired in the three most distant from the intake, and after these shots had been fired the roburite shots were fired in the places nearest to the intake, the observer at the return having in the meantime moved to a point midway between the two sets of places. In this way any possibility of the vitiation from one explosive affecting the other was obviated. The experiments were conducted in the presence of the Sub-committee. Four shots of gunpowder were fired, representing 37·3 ounces or 2·33 lbs., and two collections were made in exhausted brass cylinders.

The intake air gave no indication of the presence of carbon monoxide, whilst traces only were found in the sample collected in the return, and traces only in the two collections made after the firing of the shots.

Solid Matter Suspended in the Fumes.

The fumes produced by the firing of a shot consist, in addition to the gaseous products of the explosion, of finely divided solid matter. To collect the solid matter tubes containing glass wool were attached to the exhausted cylinders, through which the air entering the cylinder passes, and is thus filtered. The amount of such finely divided solid matter so collected was, in the majority of cases but small, and consisted chiefly of finely divided coal. The solid matter might consist in part of some of the undecomposed, or partially decomposed explosive. The examination of the solids thus collected has, however, failed to yield any noteworthy result, and in the case of roburite no evidence could be obtained of the existence among the solid matter of nitrobenzene, which is one of the possible products of the incomplete decomposition of a roburite cartridge. In some cases after the firing of roburite, the odour of nitrobenzene was observed, but beyond this I obtained no evidence of the presence of nitrobenzene or of any similar product.

The results of the experiments conducted in the mines with these three explosives show that the only distinctly injurious substances recognized in the several collections of fumes made immediately after the firing of the shot and in the samples of air in the return are carbon monoxide and sulphuretted hydrogen, and that the first of these compounds is produced by each one of the explosives, whereas the latter is produced by gunpowder alone.

Discussion of the Results.

Gaseous Products of the Detonation of Explosives.

In considering the results, it must be remembered that the normal constituents of air are the following, viz. :—Nitrogen, oxygen, carbonic acid gas, and aqueous vapour, which, on the average, are present in the proportions of :—

Nitrogen	77·95
Oxygen	20·61
Aqueous vapour	1·40
Carbonic acid gas	·04
	100·00 vols.

Neglecting the moisture, the proportion of oxygen to nitrogen is 20·9 to 79·1 per 100 volumes, or, roughly, 1 : 4. Men and animals produce similar changes in the composition of the air, reducing the proportion of oxygen and increasing the amount of carbonic acid gas. The burning of oil lamps would have practically a similar effect. The detonation of an explosive adds to the air a considerable volume of mixed gases. Gunpowder, as is well known, is an intimate mixture of charcoal, sulphur (both combustible materials), and nitre, the latter being the medium which supplies the oxygen for the burning of the combustible constituents. When gunpowder is exploded the products are, as has been shown by Sir F. Abel and Captain Noble and others, extremely complex, and amongst the gaseous products these investigators have discovered the following :—Carbonic acid gas, carbon monoxide, nitrogen, sulphuretted hydrogen, marsh gas, hydrogen, and in some cases oxygen, the chief products being carbonic acid gas, nitrogen, carbon monoxide, and sulphuretted hydrogen ; so that the effect of exploding gunpowder in a mine is, after each explosion, to add to the air a mixture of these gases, which is carried away by the air current. To form some idea of the effect which the firing, say of 7 ounces of gunpowder, would have on the air at a working place, the following calculation may be made based upon the following assumptions :—First, supposing the dimensions of a working place to be 12 feet by 4 feet 6 inches high. Secondly, imagining the air cut off at a distance of 10 feet from the face, thus giving a space of 540 cubic feet. Thirdly, assuming this air to be entirely stationary, and assuming further the volume of gaseous products from the explosion of 7 ounces of gunpowder to be diffused through such a volume of air.

Gunpowder.—Accepting Abel and Noble's results, the volume of the gases produced by the detonation of 7 ounces of gunpowder, would measure 1·92 cubic feet at a temperature of 32 degs. Fahr., and a pressure of 30 inches of mercury, having the following percentage composition :—

Carbonic acid gas	49·9	vols.
Carbon monoxide	14·1	,,
Nitrogen	33·3	,,
Sulphuretted hydrogen	2·7	,,
	100·0	,,

This volume of gas, if diluted by 540 cubic feet of air, would form a mixture containing 0·355 per cent. of the gaseous products, and this would be made up as follows :—

Carbonic acid gas	0·175	vols.
Carbon monoxide	0·05	,,
Nitrogen	0·12	,,
Sulphuretted hydrogen	0·01	,,
	0·355	,,

Roburite.—Making a similar calculation for roburite on the assumption that in the explosion of this material all the carbon is converted into carbonic acid gas, the nitrogen set free as such, and the chlorine producing hydrochloric acid, and further, that the steam produced condenses, so that the gaseous products would consist of a mixture of carbonic acid gas, nitrogen, and hydrochloric acid. Accepting these assumptions, it will then be found that the gaseous products from 7 ounces of roburite would measure 3·02 cubic feet, and have the following percentage composition :—

Carbonic acid	35·3	vols.
Nitrogen	58·9	„
Hydrochloric acid	5·8	„
	100·0	„

These gases, when mixed thoroughly with 540 cubic feet of air, would give a mixture of which they would form 0·55 per cent., which would be made up as follows :—

Carbonic acid	0·19	vols.
Nitrogen	0·33	„
Hydrochloric acid	0·03	„
	0·55	„

Tonite.—Assuming that when tonite is exploded the chemical change taking place results in the formation of barium carbonate, carbonic acid gas, nitrogen, steam, and oxygen, which should be the theoretical result of a complete decomposition of a mixture composed of equal proportions of gun-cotton and barium nitrate, the gaseous products would then consist of carbonic acid gas, nitrogen, and oxygen, and the explosion of 7 ounces of tonite would produce 2·43 cubic feet of gas, one hundred volumes of which would have the following composition :—

Carbonic acid	62·50	vols.
Nitrogen	31·25	„
Oxygen	6·25	„
	100·00	„

whilst if the 2·43 cubic feet of gaseous products be diluted with 540 cubic feet of air, a mixture would be produced containing 0·445 per cent. of these gases, which would be made up as follows :—

Carbonic acid	0·278	vols.
Nitrogen	0·139	„
Oxygen	0·028	„
	0·445	„

Summary.—These purely theoretical considerations are of service insomuch that we are able by them to form a conception of the relative vitiation resulting from the firing of equal weights of these explosives. Taking the carbonic acid as a measure of the vitiation, it will be seen that gunpowder and roburite have practically equal effects, whilst the vitiation from tonite is much higher. In the case of gunpowder, however, the carbonic acid is known to be accompanied by carbon monoxide and sulphuretted hydrogen—injurious gases, which should not theoretically exist amongst the products from the other explosives. Carbon monoxide I have found amongst the fumes from each of these explosives, and assuming this to be produced by the passage of heated carbonic acid gas over the coal, and that all the carbonic acid gas formed from 7 ounces of the explosive is thus converted into carbon monoxide, then tonite would produce the largest amount, gunpowder the next, and roburite the least. And if it be assumed that this gas be diluted by 540 cubic feet of air, then the volume of carbon monoxide in 100 volumes of such air would be as follows:—Tonite, 0·55; gunpowder, 0·40; roburite, 0·38.

Assuming the air of the mine to have the composition of ordinary air, then the mixtures produced by the diffusion through 540 cubic feet of air of the gaseous products from the 7 ounces of each of three explosives would be as follows:—

	Gunpowder.	Roburite.	Tonite.
Nitrogen	78·96 vols.	79·00 vols.	78·879 vols.
Oxygen	20·77 „	20·74 „	20·788 „
Carbonic acid gas...	0·21 „	0·23 „	0·333 „
Carbon monoxide...	0·05 „	—	—
Sulphuretted hydrogen	0·01 „	—	—
Hydrochloric acid	—	0·03 „	—
	100·00 „	100·00 „	100·000 „

In these calculations the amount of solid matter projected into the air in the shape of fumes has been entirely neglected; but in this connexion it is to be remembered that the amount of solid matter produced in the case of gunpowder is about 55 per cent. of the weight of the powder. The solids produced in the exploding of gunpowder have been found by Sir F. Abel and Captain Noble to consist of the following compounds: carbonate, sulphate, sulphocyanide, sulphide and nitrate of potassium, ammonium carbonate, charcoal and sulphur. In the case of tonite the amount of solid matter may be assumed to be about 55 per cent., whereas in the case of roburite the products are entirely gaseous.

Summarized Results of the Analyses.

Inasmuch as in the experiments made at Elemore, South Hetton, and Haswell, the results show that each of these explosives yield very similar gaseous products under the ordinary working conditions, it would appear that the problem to be solved as to the injurious action of the fumes from these several explosives is purely one of

ventilation. To institute a comparison showing how the fumes are diluted by the air current, I have prepared the following brief statement of the results of the analysis of the air made on each occasion. First, the composition of the air at the intake is given; secondly, the composition of the air at the working place immediately after the firing of a shot, and this is an average arrived at by taking the mean of the several determinations from all such collections; and thirdly, the composition of the air at the return. The results obtained in this way are the following :—

Roburite.—Elemore, February 5th, 1890.—23 shots were fired. Rate of air current, 5,100 cubic feet per minute. The composition of the air at the working place is based upon the mean of seven collections.

	Intake.	At Place immediately after firing of shot.	Return.
Nitrogen	79·010 vols.	79·71 vols.	80·220* vols.
Oxygen	20·855 ,,	20·03 ,,	19·646† ,,
Carbon dioxide ...	0·045 ,,	0·24 ,,	0·134 ,,
Carbon monoxide ...	None. ,,	0·02 ,,	Traces.
Marsh gas	0·090 ,,	—	—
	100·000 ,,	100·00 ,,	100·000 ,,

The air at the place contains about 20 volumes per 10,000 of carbonic acid more than the intake, and in the return an excess of about 9 volumes per 10,000. Further, whilst at the place the air contains 2 volumes of carbon monoxide per 10,000, traces could only be detected in the return.

South Hetton, July 22nd, 1890.—Six shots were fired. The rate of the air current was 1,184 cubic feet per minute. The composition of the air at the place is based on the mean of two collections.

	Intake.	At Place immediately after firing of shot.	Return.
Nitrogen	79·24 vols.	79·516 vols.	79·22 vols.
Oxygen	20·65 ,,	19·810 ,,	20·64 ,,
Carbon dioxide ...	0·11 ,,	0·547 ,,	0·14 ,,
Carbon monoxide ...	None.	0·127 ,,	Not found.
	100·00 ,,	100·000 ,,	100·00 ,,

These numbers are specially instructive because the samples collected at the face immediately after the firing of the shots contain a larger proportion of carbonic acid and of carbon monoxide than any other similar collection; the proportion of carbonic acid gas being, in fact, double that contained in the imaginary case in which it was assumed that the products of such an explosion were diluted by 540 cubic feet of air. Despite this, the air in the return was found to contain about 40 volumes of carbonic acid gas per 10,000 less than that collected at the place, and carbon monoxide was not detected.

* Marsh gas included, probably too high. † Probably too low.

Tonite.—South Hetton, November 22nd, 1889.—19 shots fired. Rate of air current 1,944 cubic feet per minute. Composition of air at working place immediately after firing of shot based upon six collections. An indication of the presence of carbon monoxide in the air of the return was obtained, but the method of analysis does not allow of a definite statement of the amount. Carbon monoxide forms, no doubt, part of what in the accompanying statement is put down as combustible gas, the greater part of which is doubtless marsh gas :—

	Intake.	At Place immediately after firing of shot.	Return.
Nitrogen	79·350 vols.	79·70 vols.	78·850 vols.
Oxygen	20·511 ,,	19·57 ,,	20·526 ,,
Carbonic acid ...	0·089 ,,	0·39 ,,	0·134 ,,
Combustible gas ...	0·050 ,,	0·34 ,,	0·490 ,,
	100·000 ,,	100·00 ,,	100·000 ,,

In this case the return air contains some 26 volumes of carbonic acid per 10,000 less than that collected at the place immediately after the firing of the shot, and about 5 volumes per 10,000 more than the air of the intake.

South Hetton, April 1st, 1890.—13 shots were fired. The rate of the air current, 1,614 cubic feet per minute. Composition of air at the place based on the results of the analysis of seven collections.

	Intake.	At Place immediately after firing of shot.	Return.
Nitrogen	79·48 vols.	79·58 vols.	79·44 vols.
Oxygen	20·44 ,,	20·26 ,,	20·38 ,,
Carbonic acid gas...	0·08 ,,	0·12 ,,	0·18 ,,
Carbon monoxide ...	None.	0·04 ,,	Traces.
	100·00 ,,	100·00 ,,	100·00 ,,

The return air contains some 10 volumes of carbonic acid per 10,000 more than the intake, the air at working place contains 4 volumes of carbon monoxide per 10,000, and traces only of this gas could be found in the return.

Gunpowder.—Haswell, May 14th, 1890.—24 shots were fired. Rate of the air current, 4,950 cubic feet per minute. The composition of the air at the place is based on the analysis of five collections made after the firing of the shots.

	Intake.	At Place immediately after firing of shot.	Return.
Nitrogen	79·38 vols.	79·37 vols.	79·23 vols.
Oxygen	20·53 ,,	20·49 ,,	20·57 ,,
Carbon dioxide ...	0·09 ,,	0·13 ,,	0·20 ,,
Carbon monoxide ...	None.	0·01 ,,	Traces.
	100·00 ,,	100·00 ,,	100·00 ,,

The air collected at the place as shown by the proportion of carbonic acid was evidently considerably diluted by the ventilating current, a conjecture which is also borne out by the proportion of oxygen present.

South Hetton, July 22nd, 1890.—Four shots were fired. Rate of the air current, 1,272 cubic feet per minute. The composition of the air at working place is based on the analysis of two samples collected after the firing of the shots.

	Intake.	At Place immediately after firing of shot.	Return.
Nitrogen	79·24 vols.	79·679 vols.	79·22 vols.
Oxygen	20·65 „	20·117 „	20·60 „
Carbon dioxide ...	0·11 „	0·195 „	0·18 „
Carbon monoxide ...	None.	0·009 „	Traces.
	100·00 „	100·000 „	100·00 „

Remarks on the Results.

The results at South Hetton on July 22nd, 1891, show the effect of four shots of blasting powder to be scarcely perceptible in the air of the return—a similar influence is shown by the results obtained with roburite on the same day, when six shots were also fired. And despite the fact that the air at the place is vitiated immediately after the firing of the shot, still, with such ventilation as obtains in the mines in which the experiments were conducted, the fumes are rapidly dissipated. Provided, therefore, a sufficient time is allowed to elapse for the fumes to be carried away by the air after a shot has been fired before the coal is disturbed, the air at the place must have a composition similar to that of the return, and consequently there should be no special danger arising from the use of roburite or tonite as compared with gunpowder. The danger in the case of roburite, as in all similar explosives, is to be found in the fact that the fumes produced are almost entirely gaseous, and their consequent invisibility may lead the miner to return to work sooner than he would when gunpowder is used, as the fumes from this explosive, in consequence of the considerable proportion of solids and of the characteristic odour, enable the miner to detect their presence.

That the fumes from a shot are carried quickly away from the place, and the condition of the air at the working place approximates to that of the air supplying the district, is shown by the results obtained in experiments conducted with roburite at Elemore, on March 5th, 1891, and consequently, in comparing these three explosives with one another the composition of the return air is that which should be used for such a comparison. The experiments made at Elemore on this occasion were conducted in the district already described. Two 7-inch shots of roburite having been fired at a place, I went in with the hewer who commenced work immediately after the shot had been fired. As the hewer began his work, with fumes still hanging about the place and two minutes after the firing of the shot, I collected

a sample of air. At an interval of five minutes from this time I collected a second sample, and a third after a further interval of five minutes. Samples of air in the return and in the intake were also collected. The examination of these several samples showed that traces of carbon monoxide could only be found in the first two collections, and that the air of the third collection, made some twelve minutes after the shot had been fired, contained no carbon monoxide. These results were obtained at a working place at which the volume of the air current was 188 cubic feet per minute. I am, therefore, of opinion that if an interval of five minutes is allowed to elapse after the firing of the shot before the hewer commences work, no ill effects would be experienced from the fumes produced by these explosives.

The Production of Carbon Monoxide.

The presence of carbon monoxide in the fumes produced by tonite and roburite, although theoretically this gas is not formed in the complete decomposition of these explosives, has led me to investigate the possible origin of this gas in the fumes. In all cases these explosives were fired by Bickford fuse; and experiments in the laboratory have shown that this gas is amongst the products formed when the fuse is burnt either in the air or in vacuum. Further, that the gas is produced in considerable proportion; so, no doubt, in all the experiments in the mines, some of the carbon monoxide found is to be attributed to the fuse. Again, it is possible that some of the gas may be produced by the heated carbonic acid gas passing over the coal.

Bearing upon this question I may cite the results of some experiments made with tonite and roburite. In a steel cylinder some 2 feet long by 6 inches in diameter a detonator was exploded by electricity. After the explosion the air in the cylinder was examined, and found to contain carbon monoxide. In the same cylinder a charge of 75 grains of tonite was fired with a similar detonator, the air was found to contain carbon monoxide, and also showed the reactions for nitric oxide. An experiment with 75 grains of roburite gave a result similar to tonite, save that no nitric oxide could be detected. From the proportions of carbon monoxide produced in each of these cases I conclude that the detonator is almost entirely responsible for this gas. In such experiments the charge of the detonator forms a relatively large proportion of the explosive, but such is not the case in actual practice. Still, the fact remains that in the gunpowder burnt in the Bickford fuse there is to be found a contributor to the carbon monoxide present in the fumes from both the roburite and tonite shots in the experiments in the mines.

The Production of Nitric Oxide.

The production of nitric oxide observed in the experiment with tonite just mentioned, may in all probability arise from the fact, that the conditions were such that a part of the tonite decomposed as it does when burnt. It is to be remembered that the substances produced by the burning of a mixture such as tonite, gunpowder, or

roburite are necessarily different from those obtained by the explosion of these materials, so that the nature of the compounds formed by the burning of an explosive give little or no information as to the bodies produced when it is exploded. It is well known that gunpowder burnt slowly gives nitric oxide, and I have found that when tonite is burnt in a partially exhausted vessel nitric fumes are produced, but information of this kind in connexion with roburite I have been unable to obtain, as it is difficult to get roburite to burn slowly, and in this respect it differs essentially from such mixtures as gunpowder and tonite, therein no doubt is one of the elements of safety in the use of the last-named explosive. Whilst recognizing the fact that the explosive decomposition of each of the mixtures may give rise to different substances according to the conditions under which it is exploded, the fact remains that under the ordinary working conditions of a mine I have been able only to detect in the fumes two deleterious substances, viz., carbon monoxide and sulphuretted hydrogen, and whilst carbon monoxide is produced by each one of these materials, sulphuretted hydrogen is formed by gunpowder alone.

Composition of Roburite and Tonite.

Samples of these materials have been obtained from stores at the mines, and also from the manufacturers or their agents. In the case of tonite, the results obtained show this explosive to be essentially a mixture of barium nitrate and gun-cotton, and practically in the proportions of equal weights. The analysis of different ends of a cartridge show the materials to be thoroughly well incorporated with one another. The analyses of different makes of roburite confirm its description as a mixture of ammonium nitrate and chloro-nitrobenzene. The samples of more recent manufacture contain somewhat more ammonium nitrate than those made in 1889. The proportion of ammonium nitrate in chloro-nitrobenzene is approximately 7 to 1. Analyses of different portions of a cartridge show that the constituents are thoroughly and intimately mixed.

A statement of the results of the analysis of these explosives, as also of the various samples of air collected on the different occasions, is given in the Appendices to this report.

REPORT OF THE MEDICAL EXAMINERS ON THE EFFECTS PRODUCED BY THE EXPLOSIVES.

By Dr. David Drummond and Dr. George H. Hume.

In October, 1889, we were appointed by the Explosives Committee of the Durham Coal Owners' and Miners' Associations, in conjunction with Professor Belson, to enquire into the alleged ill-effects, upon the health of those using them, of the explosives roburite and tonite. The enquiry divided itself into two parts, viz., the

chemical examination of the explosives, and of the fumes arising from their use under ordinary working conditions; and, secondly, the medical examination of cases in which injury to health was supposed to have resulted from their employment.

With regard to the first part of the enquiry, we, in conjunction with Professor Bedson and the Committee, were present during a series of experiments with roburite at Elemore, with tonite at South Hetton, and with gunpowder at Haswell. The chemical results of these experiments are dealt with in the report of Professor Bedson. We would note here, however, that the explosion of the roburite cartridges produced fumes attended by a peculiar bitter-almond smell, presumably due in part to nitrobenzene. This smell seemed specially characteristic of roburite, and it was present even when the cartridges were fired by electricity in some experiments conducted for our information in the Houghton pit. Here, however, it was only faintly perceptible; and we came to the conclusion that the decidedly unpleasant odour noticed in the experiments at Elemore was due in great part to the burning of the coverings and constituents of the fuse.

Coming to our own special share in the enquiry, we would recall first the arrangement decided upon by the Committee to secure the bringing to our notice without delay all cases of supposed illness arising from use of the explosives. At a meeting of the Committee on October 29th, 1889, it was agreed that Mr. Crawford and Mr. Guthrie should make arrangements to forward to us the names of such persons as complained, but all arrangements for the medical examinations were left to our discretion. On the 18th of December, on receipt of a telegram informing us of a case at Elemore, we proceeded with as little delay as possible to visit the patient, but found on our arrival that he was at work in the mine. Having arranged another visit with the miners' secretary at Elemore we again went there on 29th December, and met by appointment three men (including the one referred to in the telegram of the 18th) who believed that they had suffered from the effects of roburite. The results of our examination in these cases will be subsequently stated. From this date no further intimation of any case was made to us till the 4th of August, 1890. A case was then reported from Silksworth, and was seen and examined as soon as possible. In this case also the man had returned to work at the time of our visit. We think it right to emphasize the fact that during the lengthened period covered by this enquiry these two were the only cases of alleged injury from the use of the explosives of which intimation reached us in accordance with the arrangements made by the Committee.

In order, therefore, to supplement our opportunities for enquiry, we, on the 20th November, 1890, addressed a letter to the miners' secretary at each colliery in which roburite or tonite is or has been in use. In this letter we requested to be furnished with the names of any men who had suffered or were then suffering from illness believed to be due to their effects. Replies were received from ten collieries, and in three of these replies the names of alleged sufferers were given. Selecting one which contained the longest list, we arranged an interview with the men, and made a

careful enquiry into their cases. Lastly, in order to gain further information as to the use of the explosives from men in the daily habit of handling them, we met and examined a number of the deputies or shot-firers at Elemore.

It will be seen from the foregoing statement that no case of acute illness has throughout the enquiry been brought to our knowledge, and we are led to the conclusion that such cases have not occurred. The information on which we have had to form an opinion has been derived from the statements of men who had previously from some cause suffered in health, but who were not ill at the time of our examination; and, secondly, from the shot-firers.

Of the shot-firers examined, only one alleged that he had suffered from the effects of roburite. His complaints were vague in character, and appeared to depend on dyspeptic troubles, which we had reason to think were existent previous to his working with the explosive. The other shot-firers practically made no complaint.

Neither amongst the shot-firers who handle the cartridges, nor amongst the hewers who are exposed to the fumes after their explosion, did we find symptoms complained of or described in any way suggestive of nitrobenzene poisoning. We conclude that instances of nitrobenzene poisoning have not occurred; and that the nitrobenzene derivatives which gives the fumes their characteristic odour exist therein in too minute quantity to be hurtful.

We come now to consider the symptoms complained of by the men whose health in their belief had been injuriously affected. All these men were hewers who were exposed for lengthened periods to the fumes lingering amongst the coal brought down by the shots. The symptoms described by them were such as are popularly spoken of as bilious symptoms, and the more severe attacks seemed to have been accompanied by slight jaundice. They had headache, occasional vomiting, dizziness, want of appetite, want of sleep, or occasionally drowsiness. The difficulty which at once meets us in the way of tracing these symptoms to the effects of the explosives is that they belong to a class of ailments which are in our experience common amongst miners. Such ailments have their origin in the conditions of their work—the absence of light, the confined and occasionally foul air; and no doubt the carbon monoxide, which is a product of all the explosives fired in coal, is a factor in their production. But it has been ascertained in the examinations made by Professor Bedson that the amount of carbon monoxide resulting from the explosion of roburite or tonite is not practically and on an average greater than that produced by gunpowder. Moreover, it has been shown that after a very short interval this and other gases are entirely carried out of the place by the air current. We are, therefore, unable to assign the ailments complained of by the men to any poisonous or specially hurtful influence of the explosives.

JOINT STATEMENT OF CONCLUSIONS AND RECOMMENDATIONS.

By Prof. P. Phillips Bedson, Dr. David Drummond, and Dr. George H. Hume.

We tabulate the conclusions at which we have arrived as follows :—

1.—That the products of the explosion of roburite and tonite are not more deleterious than the products of the explosion of gunpowder.

2.—That with regard to the effects of the explosion of roburite no chemical evidence was obtained of the presence of nitrobenzene; and throughout the enquiry no case of nitrobenzene poisoning was met with.

3.—That with regard to the production from roburite, tonite, and gunpowder of carbon monoxide, the quantity found in average samples of air collected in the place is small, and is so quickly dissipated by the air current as to have been detected only in traces at an interval of five minutes after the firing of the shot.

4.—Upon the foregoing statement with regard to the rapid and progressive dissipation of the fumes by the air current, we base a strong recommendation that an interval of at least five minutes be allowed to elapse after the firing of the shot before the hewers re-enter the place.

5.—That as part of the gases detected in the fumes are produced by the burning of the fuse, we recommend that the cartridges be fired by electricity.

APPENDICES.

RESULTS OF THE CHEMICAL EXAMINATION OF THE FUMES FROM THE EXPLOSIVES, ROBURITE, TONITE, AND GUNPOWDER.

By Dr. P. Phillips Bedson.

Roburite.

Elemore, October 24th, 1889.

Intake.—Barometric pressure, 30·42 inches. Temperature, wet bulb, 56·5 degs. Fahr.; dry bulb, 59·5 degs. Fahr. Hygrometric state, 73·8 per cent. of that required for saturation. Rate of air current, 5,376 cubic feet per minute. Composition of air, neglecting moisture :—

	No. 1.	
Nitrogen	79·620	vols.
Oxygen	20·302	„
Carbonic acid gas	0·078	„
	100·000	„

Correcting for moisture, this becomes :—

Nitrogen	78·68	vols.
Oxygen	20·06	,,
Carbonic acid gas	0·07	,,
Moisture	1·19	,,
	100·00	,,

Return.—Temperature, 59·7 degs. Fahr., wet and dry bulb. Hygrometric state, 100 per cent. Air saturated with moisture. Composition of air :—

No. 2.		
Nitrogen and combustible gas	79·730	vols.
Oxygen	20·144	,,
Carbonic acid gas	0·126	,,
	100·000	,,

Correcting for moisture :—

Nitrogen and combustible gas	78·44	vols.
Oxygen	19·81	,,
Carbonic acid gas	0·12	,,
Moisture (aqueous vapour)	1·63	,,
	100·00	,,

Elemore, February 5th, 1890.

Intake.—Barometric pressure, *vide* Return. Temperature, wet bulb, 57·8 degs. Fahr.; dry bulb, 58·5 degs. Fahr., at the commencement. Later, wet bulb, 56·5 degs. Fahr.; dry bulb, 57·5 degs. Fahr. Hygrometric state, 93·1 per cent. of saturation. Rate of air current, measured at the return. Composition of air, neglecting moisture :—

No. 3.		
Nitrogen	79·010	vols.
Combustible gas (marsh gas)	0·090	,,
Oxygen	20·855	,,
Carbonic acid gas	0·045	,,
	100·000	,,

Introducing moisture :—

Nitrogen	77·86	vols.
Marsh gas	0·09	,,
Oxygen	20·55	,,
Carbonic acid gas	0·04	,,
Moisture	1·46	,,
	100·00	,,

Return.—Barometric pressure, 30·15 inches. Temperature, wet and dry bulb, 60·3 degs. Fahr. (mean). Hygrometric state, air saturated with aqueous vapour. Rate of air current, 5,100 cubic feet per minute. Composition of air :—

	No. 4. Neglecting Moisture.	Aqueous Vapour introduced.
Nitrogen ... ... } Combustible gas ... ... }	80·220 vols.	78·89 vols.
Oxygen	19·646 „	19·32 „
Carbonic acid gas	0·134 „	0·13 „
Carbon monoxide	Traces.	Traces.
Aqueous vapour	—	1·66 „
	100·000 „	100·00 „

Composition of the air collected in the cylinders.—Cylinder I. filled at the place A after firing of the second shot; shots were 4½ and 4 inches respectively. Cylinder II. filled after firing second shot at place C; shots were 6 and 4 inches respectively. Cylinder III. filled after firing second shot at place H; shots were 5¼ inches each.

	No. 5. Cylinder I.	No. 6. Cylinder II.	No. 7. Cylinder III.
Nitrogen ... ... } Combustible gas ... }	80·17 vols.	79·99 vols.	79·400 vols.
Oxygen	19·73 „	19·89 „	20·581 „
Carbonic acid gas ...	0·06 „	0·10 „	
Carbon monoxide ...	0·04 „	0·02 „	0·019 „
	100·00 „	100·00 „	100·000 „

Composition of air collected in pipettes:—

Collection *a*, made after firing second shot at place B, No. 8.
„ *b*, „ „ first „ place E, No. 9.
„ *c*, „ „ second „ place F, No. 10.
„ *d*, „ „ „ „ place I, No. 11.

	No. 8.	No. 9.	No. 10.	No. 11.
Nitrogen and combustible gas ...	79·93 vols.	79·68 vols.	79·72 vols.	79·34 vols.
Oxygen and carbonic acid gas ...	20·07 „	20·32 „	20·28 „	—
Oxygen	—	—	—	20·13 „
Carbonic acid gas	—	—	—	0·53 „
	100·00 „	100·00 „	100·00 „	100·00 „

No. 11 contained traces of carbon monoxide.

South Hetton, July 22nd, 1890.

Intake.—Barometric pressure, *vide* Return. Temperature, dry bulb, 64 degs. Fahr.; wet bulb, 63 degs. Fahr. Hygrometric state, 92·25 per cent. of saturation. Rate of air current, *vide* Return. Composition of air :—

	No. 12. Dry Air.	No. 12. Moisture Included.
Nitrogen and combustible gas ...	79·24 vols.	77·92 vols.
Oxygen	20·65 „	20·31 „
Carbonic acid gas	0·11 „	0·10 „
Aqueous vapour	—	1·67 „
	100·00 „	100·00 „

Return.—Temperature, dry bulb, 62·3 degs. Fahr.; wet bulb, 62·3 degs. Fahr. Barometric pressure, 30·59 inches. Hygrometric state, air saturated with moisture. Rate of air current, 1,184 cubic feet per minute, Composition of air :—

	No. 13. Dry Air.	No. 13. Moisture Included.
Nitrogen and marsh gas ...	79·22 vols.	77·84 vols.
Oxygen	20·64 „	20·28 „
Carbonic acid gas	0·14 „	0·13 „
Carbon monoxide...	None.	None.
Aqueous vapour	—	1·75 „
	100·00 „	100·00 „

Composition of air collected in cylinders:—

Cylinder I. filled after firing second shot at place A, No. 14.
„ III. „ „ „ B, No. 15.

	No. 14.	No. 15.
Nitrogen and marsh gas ...	79·44 vols.	79·576 vols.
Oxygen	19·34 „	20·280 „
Carbonic acid gas	0·98 „	0·114 „
Carbon monoxide	0·24 „	0·014 „
	100·00 „	99·984 „

TONITE.

South Hetton, November 22nd, 1889.

Intake.—Temperature, dry bulb, 62 degs. Fahr.; wet bulb, 61 degs. Fahr. Barometric pressure, *vide* Return. Hygrometric state, 90·6 per cent. of saturation. Rate of current measured in the Return. Composition of the air :—

	No. 16. Dry Air.	No. 16. Moisture Included.
Nitrogen	79·350 vols.	78·06 vols.
Oxygen	20·511 „	20·17 „
Carbonic acid gas	0·089 „	0·08 „
Marsh gas	0·050 „	0·04 „
Moisture	—	1·65 „
	100·000 „	100·00 „

Return.—Temperature, dry bulb, 62·5 degs. Fahr.; wet bulb, 62·5 degs. Fahr. Barometric pressure, 30·61 inches. Hygrometric state, saturated with moisture. Rate of current, 1,944 cubic feet per minute. Composition of air :—

	No. 17. Dry Air.	No. 17. Moisture Included.
Nitrogen	78·850 vols.	77·49 vols.
Oxygen	20·526 „	20·17 „
Carbonic acid gas	0·134 „	0·13 „
Marsh gas	0·490 „	0·48 „
Aqueous vapour	— „	1·73 „
	100·000 „	100·00 „

Composition of air collected in the cylinders :—

Cylinder I. filled after firing third shot at place B, No. 18.
„ II. „ „ second „ „ D, No. 19.
„ III. „ „ „ „ „ H, No. 20.

	No. 18.	No. 19.	No. 20.
Nitrogen	80·25 vols.	—	—
Combustible gas (marsh gas and carbon monoxide)		0·28 vols.	0·42 vols.
Oxygen	19·75 „	—	—
Carbonic acid gas		0·32 „	0·17 „
	100·00 „		

Composition of air collected in pipettes :—

Collection *b*, made after firing second shot at place E, No. 21.
„ *c*, „ first „ „ F, No. 22.
„ *d*, „ second „ „ I, No. 23.

	No. 21.	No. 22.	No. 23.
Nitrogen and combustible gas...	79·91 vols.	81·26 vols.	79·73 vols.
Oxygen	19·33 „	18·74 „	19·94 „
Carbonic acid gas	0·76 „		0·33 „
	100·00 „	100·00 „	100·00 „

South Hetton, April 1st, 1890.

Intake.—Temperature, dry bulb, 62 degs. Fahr.; wet bulb, 61·5 degs. Fahr. Barometric pressure, *vide* Return. Hygrometric state, 93·5 per cent of saturation. Rate of current measured in the Return. Composition of air :—

	No. 24. Dry Air.	No. 24. Moisture Included
Nitrogen	79·48 vols.	78·16 vols.
Oxygen...	20·44 „	20·10 „
Carbonic acid gas	0·08 „	0·08 „
Carbon monoxide	None.	None.
Moisture	— „	1·66 „
	100·00 „	100·00 „

Return.—Temperature, dry bulb, 62·8 degs. Fahr.; wet bulb, 62·5 degs. Fahr. Barometric pressure, 30·92 inches. Hygrometric state, 97·4 per cent. of saturation. Rate of current, 1,614 cubic feet per minute. Composition of air :—

	No. 25. Dry Air.	No. 25. Moisture Included.
Nitrogen	79·44 vols.	78·06 vols.
Oxygen...	20·38 „	20·03 „
Carbonic acid gas	0·18 „	0·18 „
Carbon monoxide	Traces.	Traces.
Aqueous vapour	—	1·73 „
	100·00 „	100·00 „

Composition of air collected in cylinders :—

Cylinder I., filled after firing second shot at place A, No. 26.
„ II., „ third „ „ B, No. 27.
„ III., „ fourth „ „ E, No. 28.

	No. 26.	No. 27.	No. 28.
Nitrogen	79·468 vols.	79·616 vols.	79·601 vols.
Oxygen	20·378 „	20·295 „	20·305 „
Carbonic acid gas ..	0·113 „	0·065 „	0·035 „
Carbon monoxide ...	0·041 „	0·024 „	0·059 „
	100·000 „	100·000 „	100·000 „

Composition of air collected in pipettes :—

Collection *a*, made after firing second shot at place B, No. 29.
„ *b*, „ „ „ C, No. 30.
„ *c*, „ „ „ E, No. 31.
„ *d*, „ third „ E, No. 32.

	No. 29.	No. 30.	No. 31.	No. 32.
Nitrogen	79·450 vols.	80·120 vols	79·260 vols.	79·950 vols.
Oxygen	20·315 „	19·726 „	20·558 „	19·932 „
Carbonic acid gas	0·235 „	0·154 „	0·182 „	0·118 „
	100·000 „	100·000 „	100·000 „	100·000 „

GUNPOWDER.

Haswell, May 14th, 1890.

Intake.—Temperature, dry bulb, 62 degs. Fahr.; wet bulb, 61·5 degs. Fahr. Barometric pressure, *vide* Return. Hygrometric state, 95·2 per cent. of saturation. Rate of air current measured in the Return. Composition of air :—

	No. 33. Dry Air.	No. 33. Moisture Included.
Nitrogen	79·38 vols.	78·05 vols.
Oxygen	20·53 „	20·19 „
Carbonic acid gas	0·09 „	0·09 „
Carbon monoxide	None.	None.
Aqueous vapour	—	1·67 „
	100·00 „	100·00 „

Return.—Temperature, dry bulb, 60·7 degs. Fahr.; wet bulb, 60·2 degs. Fahr. Barometric pressure, 30·01 inches. Hygrometric state, 95·2 per cent. of saturation. Rate of air current, 4,950 cubic feet per minute. Composition of air :—

	No. 34. Dry Air.	No. 34. Moisture Included.
Nitrogen	79·42 vols.	78·100 vols.
Oxygen	20·51 „	20·180 „
Carbonic acid gas	0·07 „	0·068 „
Carbon monoxide	Traces.	Traces.
Aqueous vapour	—	1·652 „
	100·00 „	100·000 „

Composition of air collected in cylinders :—

Cylinder I., filled after firing third shot at place B, No. 35.
„ II., „ „ „ C, No. 36.
„ III., „ first „ E, No. 37.

	No. 35.	No. 36.	No. 37.
Nitrogen	79·6395 vols.	79·300 vols.	79·4 vols.
Oxygen	20·2550 „	20·635 „	20·5 „
Carbonic acid gas ...	0·0950 „	0·065 „	0·1 „
Carbon monoxide ...	0·0105 „	Traces.	Traces.
	100·0000 „	100·000 „	100·0 „

Composition of air collected in pipettes :—

Collection *a*, made after firing first shot at place C, No. 38.
„ *b*, „ second „ E, No. 39.
„ *c*, „ first „ F, No. 40.

	No. 38.	No. 39.	No. 40.
Nitrogen	79·36 vols.		79·410 vols.
Oxygen	20·64 ,,	Lost.	20·406 ,,
Carbonic acid gas ...			0·184 ,,
	100·00 ,,		100·000 ,,

South Hetton, July 22nd, 1890.

Intake.--Temperature, 64 degs. Fahr., dry bulb.; 63 degs. Fahr., wet bulb Barometric pressure, *vide* Return. Hygrometric state, 92·25 per cent. of saturation. Rate of air current measured in the Return. Composition of air :—

	No. 41. Dry Air.	No. 41. Moisture Included.
Nitrogen and combustible gas ...	79·24 vols.	77·92 vols.
Oxygen	20·65 ,,	20·31 ,,
Carbonic acid gas	0·11 ,.	0 10 ,,
Aqueous vapour	—	1·67 ,.
	100·00 ,,	100·00 ,,

Return.—Temperature, dry bulb, 63·2 degs.; wet bulb, 63·0 degs. Barometric pressure, 30·62 inches. Hygrometric state, 97·4 per cent. of saturation. Rate of air current, 1,272 cubic feet per minute. Composition of air :—

	No. 42. Dry Air.	No. 42. Moisture Included.
Nitrogen	79·22 vols.	77·840 vols.
Oxygen	20·60 ,,	20·300 ,,
Carbonic acid gas	0·18 ,,	0·118 ,.
Carbon monoxide	Traces.	Traces.
Aqueous vapour	—	1·742 ,,
	100·00 ,,	100·000 ,.

Composition of air collected in cylinder :—

Cylinder IV., filled after firing the first shot at place E, No. 43.
,, II., ,, ,, ,, F, No. 44.

	No. 43.	No. 44.
Nitrogen	79·732 vols.	79·643 vols.
Oxygen	20·090 ,,	20·145 ,,
Carbonic acid gas	0·169 ,,	0·212 ,,
Carbon monoxide	0·009 ,,	Traces.
	100·000 ,,	100·000 ,,

EXPERIMENTS CONDUCTED AT ELEMORE ON MARCH 5TH, 1891, WITH A VIEW TO ASCERTAIN THE RATE OF REMOVAL OF THE FUMES.

Temperature, dry bulb, 62 degs. Fahr.; wet bulb, 61 degs. Fahr. Hygrometric state, 90·6 per cent. of saturation. Barometric pressure, 30·34 inches. Rate of air current, 188 cubic feet per minute. Composition of air in the several samples after firing the second shot at place B:—

Collection *a*, made two minutes after shot fired ... ... No. 45.
Cylinder I., filled seven „ „ ... ... No. 46.
„ II., „ twelve „ „ ... ... No. 47.
Collection *b*, made in return twelve minutes after shot fired No. 48.
„ *c*, „ intake ... ... No. 49.

	No. 45.	No. 46.	No. 47.	No. 48.	No. 49.
Nitrogen	79·80 vols.	79·97 vols.	79·78 vols.	79·51 vols.	79·54 vols.
Oxygen	20·03 „	19·82 „	20·10 „	20·36 „	20·36 „
Carbonic acid gas ...	0·17 „	0·21 „	0·12 „	0·13 „	0·10* „
Carbon monoxide	Traces.	Traces.	Not found.	—	—
	100·00 „	100·00 „	100·00 „	100·00 „	100·00 „

COMPOSITION AND ANALYSIS OF ROBURITE.

Roburite is an intimate mixture of chlorinated dinitrobenzene and ammonium nitrate. The dinitrobenzene $C_6H_4(NO_2)_2$ is obtained from benzene C_6H_6 by the action of nitric acid. This compound is by the action of chlorine converted into chloro-dinitrobenzene, which in the molten state is run into warm and powdered ammonium nitrate and the two thoroughly incorporated. Roburite varies slightly in colour from a light yellow to a light brown, and it has an odour resembling that of nitrobenzene. Roburite can only be got to burn with difficulty, as the chlorinated dinitrobenzene volatilizes, leaving the ammonium nitrate, which is ultimately decomposed. When exploded it is assumed that the following chemical reaction takes place:—

Chloro-dinitrobenzene.		Ammonium Nitrate.		Carbonic Acid Gas.		Nitrogen.		Water.		Hydrochloric Acid.
$C_6H_3Cl(NO_2)_2$	+	$9NH_4NO_3$	=	$6CO_2$	+	$20N$	+	$19H_2O$	+	HCl.
202·5		720		264		280		342		36·5

From the results of the analysis of several samples of roburite, the following have been selected:—No. 50 bore the manufacturer's mark and was dated December 19th, 1889; No. 51 bore the manufacturer's mark and was dated September 24th, 1890:—

* This somewhat high figure for carbonic acid gas may be explained by the fact, that several members of the Sub-committee and others had been at this point some little time previous to the collection.

	No. 50.	No. 51.
Moisture	1·14	0·66
Ammonium nitrate	83·35	86·30
Chloro-dinitrobenzene (soluble in ether) ...	11·67*	11·74†
Matter insoluble in ether and in water ...	3·14	1·09
Fixed residue	0·70	0·21
	100·00	100·00

Analysis of different ends of a cartridge showed the materials to be thoroughly well mixed.

Composition and Analysis of Tonite.

Tonite is a mixture of equal parts of gun-cotton ($C_{12}H_{14}(NO_3)_6O_{10}$) and barium nitrate ($Ba2NO_3$). The mixture is compressed into cylindrical cartridges, provided at one end with an aperture for the insertion of the detonator, and the whole covered with paper dipped into paraffin wax. When exploded it may be assumed that the chemical change taking place would be represented as follows :—

Barium Nitrate.		Cellulose Hexa-nitrate or Gun-Cotton.		Barium Carbonate.		Carbonic Acid Gas.		Water.		Nitrogen.		Oxygen.
$2Ba2NO_3$	+	$C_{12}H_{14}(NO_3)_6O_{10}$	=	$2BaCO_3$	+	$10CO_2$	+	$7H_2O$	+	$5N_2$	+	O
522		594		394		440		126		140		16

Analysis of a sample obtained from South Hetton gave the following results :—

	No. 52.
Barium nitrate...	48·21
Potassium nitrate	1·77
Gun-cotton	49·21
Moisture	1·58
	100·77

Analysis of different parts of the same cartridge showed the materials to be well mixed with one another.

* The chloro-dinitrobenzene melted between 78·82° C.

† The chloro-dinitrobenzene melted at 85° C.

REPORT OF THE ENGINEER ON THE EXPERIMENTS WITH EXPLOSIVES AT ELEMORE, HASWELL, AND SOUTH HETTON COLLIERIES.

By M. Walton Brown.

Elemore Colliery, October 24th, 1889.

The Main Coal seam in the New Drift Way has a mean section of about 4 feet 6 inches, the roof being coal 1 foot 6 inches, and stone 6 inches, and the thill being white seggar. The wide bords are driven about 15 feet wide, and all walls and narrow bords are about 9 feet wide. Under ordinary circumstances the working places are not nicked, and generally the kirving, at the bottom of the seam, varies from 2½ feet to 3 feet under, and about 1 foot 8 inches high at the front or foreside.

The explosive used was roburite, fired by means of Bickford white tape fuse, and R/6 detonators, charged and stemmed in the shot-hole of 2 inches diameter in the ordinary manner by the deputy; the soft seggar clay stemming being prepared by the hewer for use.

During the course of the experiments the following persons were present in the district between the points M and N, traversed by the air :—

Ordinary—	Hewers	12		
	Putters	3		
	Deputies	2		
		—	17	
Extra-ordinary—	Officials	9		
	Committee, etc.	19		
		—	28	
			—	45

Dr. Bedson conducted other observations which are recorded in the schedule of experiments.

Dr. Bedson's assistants were stationed at the points M and N (see Fig. 3, Plate XXXV.), and conducted observations as under :—

At M—Aspirator I. was filled from 3·32 to 4·34 p.m.

At N— „ II. „ 3·35 to 5·3 p.m.

Place.	Time.	Barometer.	Thermometer. Wet.	Thermometer. Dry.	Relative Humidity.
	p.m.	Inches.	Degs.	Degs.	
At bank	2·0	29·66	—	61·0	—
„	6·3	29·66	53·0	60·0	62
At bottom of pit ...	2·5	30·44	—	66·0	—
„ ...	6·0	30·45	—	65·0	—
At M...	3·37	30·42	56·5	59·5	82
„	4·17	30·42	56·5	59·5	82
At N...	3·40	—	59·7	59·7	100
„	4·35	—	59·5	59·5	100

North Flat, October 24th, 1889.

Place.			Section of Seam.	Kirving.			Shot Hole.		Fuse.		Shot.			Time of Ignition.	Remarks.	
Position on Plan.	Description.	Width.		Length.	Depth under.	Height at Fore-side.	Length.	Position in Place.	Length.	Time of Burning.	Length of Cartridge.	Weight of Explosive.	Number.			
		Feet.	Ft. In.	Feet.	Ft. In.	Inches.	Ft. In.		Ft. In.	Secs.	Inches.	Ozs.		P.M.		
A	Wall ...	9	4 6	9	2 6	20	2 9	Left ...	3 0	55	7	4	1	3 30	Average shot.	
							2 9	Right ...	3 0	53	6	3·42	2	3 39	Do.	
B	Bord ...	9	4 6	9	3 0	19	3 3	Left ...	3 2	64	7	4	3	3 50	Do.	aspirator F filled.
							3 0	Right ...	3 2	72	4½	2·57	4	4 0	Do.	sample *a* taken.
C	Bord ...	15	4 6	10½	2 6	24	2 2	Left ...	2 4	46	5	2·85	5	4 15	Do.	aspirator E filled.
					3 0	24	2 10	Right ...	3 0	60	7	4	6	4 25	Do.	sample *b* taken.
D	Bord ...	16½	4 6	9	3 0	22	2 6	Left ...	2 8	50	7	4	7	4 35	Heavy shot;	aspirator C filled; sample *c* taken.
							2 6	Right ...	2 8	52	7	4	8	4 50	Do.	sample *d* taken.
E	Wall ...	9	4 6	9	2 6	18	2 0	Left ...	2 2	39	7	4	9	5 5	Average shot;	aspirator D filled; sample *e* taken.
							2 0	Right ...	2 2	38	7	4	10	5 20	Do.	sample *f* taken.
F	Bord ...	9	4 6	9	2 0	18	*	Left ...	2 4	*	7	4	22	From 3·30 to 4·40 p.m. inclusive.	Do.	
							*	Right ...	2 4	*	7	4	23		Do.	
G	Wall ...	9	4 6	9	2 6	20	*	Left ...	2 8	*	7	4	20		Do.	
							*	Right ...	2 8	*	7	4	21		Do.	
H	Wall ...	9	4 6	9	3 0	19	*	Left ...	2 8	*	7	4	18		Do.	
							*	Right ...	2 8	*	7	4	19		Do.	
I	Bord ...	15	4 6	9	2 6	19	*	Left ...	2 8	*	7	4	16		Do.	
							*	Right ...	2 8	*	7	4	17		Do.	
J	Wall ...	9	4 6	9	3 0	22	*	Left ...	2 10	*	7	4	14		Do.	
							*	Right ...	2 10	*	7	4	15		Do.	
K	Bord ...	15	4 6	4	2 9	21	*	Left ...	2 10	*	7	4	13		Do.	
L	Bord ...	15	4 6	9	3 0	18	*	Left ...	2 10	*	7	4	11		Do.	
							*	Right ...	2 10	*	7	4	12			
								Totals...	62 2	...	155½	88·84				

* Not recorded.

Place.	Time. p.m.	Volume of Air. Cubic ft. per minute.
At M	3·37	5,040
,, ...	4·17	5,712
	Mean	5,376

SOUTH HETTON COLLIERY, NOVEMBER 22ND, 1889.

The experiments were conducted in the Fifth West Flat, North-East Bank, in the Main Coal seam, lying at a depth of about 840 feet. The section of the seam in this district varied from 5 feet 3 inches to 6 feet, the mean being about 5 feet 7 inches, with ½ inch to 1 inch of stone band lying some 5 inches from the roof. The bords and walls are both driven about 12 feet wide. The working places are not nicked; the kirving is usually made at the top of the seam, varying from 3 to 4 feet over, and from 7 to 12 inches in height at the front or foreside.

Tonite was used in these experiments. It is made up into cylindrical masses, fitted at one end with a round hole for the insertion of the detonator. The tonite cartridges are wrapped in paper made water-proof by dipping into melted paraffin wax. These prepared cartridges are surrounded with the Trench flame-extinguishing compound mixture, packed into a brown paper cylindrical case. All detonators were fired with Bickford fuse, ignited by Bickford ignitors. The shot-holes were about 1¼ inches diameter, and stemmed in the ordinary manner with pounded soft shale by the hewer.

The number of persons in this district between the points M and N traversed by the air during the course of the experiments was:—

Ordinary—	Hewers	9		
	Putters	3		
	Deputies	2		
		—	14	
Extra-ordinary—	Officials	5		
	Committee	6		
		—	11	
			—	25

The observations conducted by Dr. Bedson are recorded in the schedule of experiments.

Dr. Bedson's assistants were stationed at M and N (see Fig. 4, Plate XXXVI.), and conducted experiments as under:—

At M—Aspirator I. was filled from 2·33 to 3·35 p.m., and two collections were made in pipettes.

At N—Aspirators II. and III. were filled from 2·45 to 4·10 and 4·12 p.m. respectively, and two collections were made in pipettes.

FIFTH WEST FLAT, NOVEMBER 22ND, 1889.

Place.			Section of Seam.	Kirving at Top of Seam.			Shot Hole.		Fuse.	Shot.		Time of Ignition.	Remarks.	
Position on Plan.	Description.	Width.		Length.	Depth under.	Height at Fore-side.	Length.	Position in Place.	Length.	Weight of Explosive.	Number.			
		Feet.	Ft. In.	Feet.	Ft. In.	Inches.	Ft. In.		Feet.	Ozs.		P.M.		
A	Bord ...	12	5 3	10½	3 6	9	3 3	Middle, 5 in. from thill.	3¼	5	1*	2 15	Average shot.	
							3 3	Right	3¼	5	2*	2 20	Do.	
B	Bord ...	12½	5 9	12½	4 0	10	3 3	Middle ...	3¼	7	3*	2 30	Do.	
							3 6	Right ...	3¼	5	4*	2 35	Do.	
							3 6	Left	3¼	5	5*	2 40	Good shot;	cylinder I. filled, behind the brattice of place.
C	Wall ...	12	5 3	12	3 6	10	3 4	Right	3¼	5	6	2 50	Do.	
							3 4	Left	3¼	5	7	2 53	Do.	sample *a* taken.
D	Bord ...	12	5 3	7	3 6	12	3 6	Middle ...	3¼	7	8	3 0	Do.	
					3 9	12	3 4	Left	3¼	5	9	3 5	Do.	cylinder II. filled.
E	Wall ...	12½	5 6	6	3 6	7	3 3	Middle ...	3¼	7	10	3 15	Bad shot.	
							3 3	Left	3¼	7	11	3 18	†Average shot;	sample *b* taken.
F	Wall ...	12	5 6	7	3 6	10	3 0	Middle ...	3	5	12	3 20	Fast shot;	sample *c* taken.
							3 0	Right	3	5	13	3 25	Bad shot.	
G	Wall ...	12	5 9	5½	3 3	10	3 0	Middle ...	3	5	14	3 28	‡ Do.	
							3 0	Left	3	5	15	3 30	‡ Do.	
H	Bord ...	13	5 10	8	4 3	12	3 10	Left	3¾	5	16	3 32	Good shot.	
							3 10	Right	3¾	7	17	3 38	Do.	cylinder III. filled.
I	Bord ...	12	6 0	7	3 0	10	2 10	Middle ...	3	7	18	3 40	Bad shot.	
							2 10	Left	3	5	19	3 45	Average shot;	sample *d* taken.
								Totals ...	62¾	107				

* Stemmed by deputy. † This shot produced a large volume of smoke. ‡ Not sufficiently kirved.

Place.	Time.	Barometer.	Thermometer. Wet.	Thermometer. Dry.	Relative Humidity.
	a.m.	Inches.	Deg.	Deg.	
At bank	11·30	29·70	41·0	43·7	79
At bottom of pit...	11·35	30·51	57·0	59·0	88
	p.m.				
At M	2·38	—	61·0	62·0	94
„	3·23	—	61·0	62·0	94
At N	2·50	30·61	62·5	62·5	100
„	4·10	30·61	62·5	62·5	100

Place.	Time.	Velocity of Air.	Area of Place of Measurement.	Volume of Air.
	p.m.	Feet per Minute.	Square Feet.	Cubic ft. per minute.
At N	2·40	111	6 ft. by 3 ft. = 18 sq. ft.	1,998
„	2·50	79		1,422
„	3·25	133		2,394
„	3·40	102		1,836
„	4·10	114		2,052
Mean		108	18	1,944

Observations with a Pieler lamp were made at N:—

At 2·40 p.m. the flame was 2 inches high.

„ 4·15 „ „ 1½ „

Elemore Colliery, February 5th, 1890.

The experiments were made in the same district as the experiments of October 24th, 1889.

The explosive roburite was also used under the same conditions.

The following persons were present in the district, between the points M and N traversed by the air-current, during the course of the experiments:—

Ordinary—	Hewers	12	
	Putters	3	
	Deputies	2	
		—	17
Extra-ordinary—	Officials	8	
	Committee	6	
		—	14
			— 31

The observations noted on the schedule of experiments were conducted by Dr. Bedson.

Dr. Bedson's assistants were stationed at the points M and N (see Fig. 5, Plate XXXVII.), and made the following observations:—

At M—Aspirator I. filled from 2·5 to 3·5 p.m.

At N— „ II. „ 2·20 „ 3·45 p.m.

North Flat, February 5th, 1890.

Place.			Section of Seam.	Kirving.			Shot Hole.		Fuse.	Shot.			Time of Ignition.	Remarks.
Position on Plan.	Description.	Width.		Length.	Depth under.	Height at Foreside.	Length.	Position in Place.	Length.	Length of Cartridge.	Weight of Explosive.	Number.		
		Feet.	Ft. In.	Feet.	Ft. In.	Inches.	Ft. In.		Ft. In.	Inches.	Ozs.		P.M.	
A	Wall ...	9	4 6	9	2 0	18	2 0	Right ...	2 3	4½	2·57	1	2 15	Bad shot.
							1 6	Left ...	2 0	4	2·28	2	2 20	Fast shot; cylinder I. filled.
B	Bord ...	9	4 6	9	2 6	19	2 3	Right ...	2 4	6	3·43	3	2 30	Good shot.
							2 0	Left ...	2 3	5½	3·14	4	2 35	Do. sample *a* taken.
C	Wall ...	9	4 6	9	2 6	20	2 6	Right ...	2 8	6	3·43	5	2 45	Do.
							2 0	Left ...	2 2	4	2·28	6	2 50	Do. cylinder II. filled.
D	Crosscut	9	4 6	9	2 9	18	2 6	Right ...	2 7	6½	3·72	7	3 0	Do.
							2 0	Left ...	2 3	5½	3·14	8	3 5	Do.
E	Wall ...	9	4 6	9	2 0	18	2 0	Right ...	2 2	6	3·43	9	3 10	Average shot; sample *b* taken.
							2 0	Left ...	2 2	5	2·86	10	3 20	Do.
F	Wall ...	9	4 6	9	2 3	21	2 0	Right ...	2 2	5	2·86	11	3 30	Do.
							2 0	Left ...	2 3	5½	3·14	12	3 35	Do. sample *c* taken.
G	Bord ...	9	4 6	9	2 3	20	2 0	Right ...	2 3	6	3·43	13	3 40	Fast shot.
H	Bord ...	9	4 6	9	2 0	18	1 9	Right ...	2 0	5½	3·14	14	3 50	* Do.
							1 9	Left ...	2 0	5½	3·14	15	4 0	Do Do. cylinder III. filled.
I	Bord ...	9	4 6	9	2 0	18	2 0	Left ...	2 3	5	2·86	16	4 10	Fair shot.
							2 0	Right ...	2 3	6	3·43	17	4 15	Good shot; sample *d* taken.
J	Bord ...	15	4 6	8	2 0	18	2 0	Left ...	2 3	6	3·43	22	3 0	Do.
							2 0	Right ...	2 3	6	3·43	23	3 5	Do.
K	Wall ...	9	4 6	9	2 9	16	2 6	Left ...	2 8	7	4·	20	2 35	Do.
							2 6	Right ...	2 8	7	4·	21	2 40	Do.
L	Wall ...	9	4 6	9	2 9	16	2 6	Left ...	2 8	7	4·	18	2 15	Do.
							2 6	Right ...	2 8	7	4·	19	2 20	Do.
								Totals ...	53 2	131½	75·14			

* Right side of jud was nicked.

Place.	Time.	Barometer.	Thermometer. Wet.	Thermometer. Dry.	Relative Humidity.
	p.m.	Inches.	Degs.	Degs.	
At bank	12·55	29·46	—	42·0	—
,, ...	5·5	29·56	36·0	39·0	77
At bottom of pit ...	1·10	30·16	59·0	65·0	68
,, ,, ...	4·45	30·20	61·0	66·0	73
At M	2·10	—	57·8	58·5	95
,, ...	2·55	—	56·5	57·5	93
At N...	2·33	30·16	60·8	60·8	100
,, ...	3·0	30·15	60·3	60·3	100
,, ...	3·30	30·15	60·4	60·4	100

Place.	Time.	Velocity of Air.	Area of Place of Measurement.	Volume of Air.
	p.m.	Feet per minute.	Square feet.	Cubic ft. per minute.
At N... ...	2·33	164	30	4,920
,, ...	3·0	183	30	5,490
,, ...	3·30	164	30	4,920
Mean		170	30	5,100

SOUTH HETTON COLLIERY, APRIL 1ST, 1890.

The experiments were made in the same district as visited on November 22, 1889.

Tonite was again used, and under the same conditions.

During the experiments the number of persons present in the district, between the points M and N traversed by the air, was :—

Ordinary—	Hewers	5	
	Putters	2	
	Deputy	1	
		—	8
Extra-ordinary—Officials		5	
	Committee	6	
		—	11
			— 19

Dr. Bedson's personal experiments are recorded in the schedule of experiments.

His assistants were placed at the points M and N (see Fig. 6, Plate XXXVIII.), where the following observations were recorded :—

At M—Aspirator I. was filled from 1·42 to 2·33 p.m.

At N ,, II. ,, 1·50 ,, 3·5 p.m.

,, ,, III. ,, 1·50 ,, 3·5 p.m.

Place.	Time.	Barometer.	Thermometer. Wet.	Thermometer. Dry.	Relative Humidity.
	a.m.	Inches.	Degs.	Degs.	
At bank	11·0	29·98	42·0	47·0	67
At bottom of pit ...	11·15	30·78	49·0	52·0	80
	p.m.				
At M	1·45	—	61·5	62·0	97
,, ...	2·25	—	61·4	62·0	97
At N	1·55	30·92	62·5	62·8	97
,, ...	2·50	30·92	62·5	62·8	97
,, ...	3·10	30·92	63·0	63·0	100*

* About ten persons present.

FIFTH WEST FLAT, APRIL 1ST, 1890.

PLACE.			Section of Seam.	KIRVING AT TOP OF SEAM.			SHOT HOLE.		FUSE.		SHOT.		Time of Ignition.	REMARKS.	
Position on Plan.	Description.	Width.		Length.	Depth under.	Height at Foreside.	Length.	Position in Place.	Length.	Time of Burning.	Weight of Explosive.	Number.			
		Feet.	Ft. In.	Feet.	Ft. In.	Inches.	Ft. In.		Feet.	Secs.	Ozs.		P.M.		
A	Wall ...	14	5 3	8	3 6	16	2 9	Middle ...	3	*	5	1	1 40	Good shot	
							2 9	Left side ...	3	*	5	2	1 45	Do.	cylinder I. filled.
B	Bord ...	13	5 11	13	3 6	15	2 10	Middle, 9 in. from bottom.	3	*	5	3	1 55	Do.	
							2 10	Left, do. ...	3	*	5	4	2 0	Do.	sample *a* taken.
							2 9	Right, do. ...	3	*	7	5	2 2	Do.	cylinder II. filled.
C	Wall ...	14	5 10	8	4 0	12	3 0	Middle, 12 in. from bottom.	3	*	7	6	2 15	Do.	
							3 0	Left, do. ...	3	*	5	7	2 20	Do.	sample *b* taken.
D	Bord ...	13	5 8	8	3 3	14	2 11	Middle, 18 in. from bottom.	3	85	5	8	2 30	Do.	
					3 3	14	2 11	Left, do. ...	3	70	5	9	2 32	Do.	
E	Wall ...	13	6 0	13	3 6	13	2 11	Left middle, 16 in. from bottom	3	*	5	10	2 45	Do.	
					3 4	13	2 11	Right middle..	3	*	5	11	2 47	Do.	sample *c* taken.
					3 8	13	2 11	Right... ...	3	*	5	12	2 50	Do.	sample *d* taken.
					3 4	13	2 11	Left	3	*	7	13	2 55	Do.	cylinder III. filled.
								Totals ...	39	...	71				

* Not recorded.

Place.	Time.	Velocity of Air.	Area of Place of Measurement.	Volume of Air.
	p.m.	Feet per minute.	Square feet.	Cubic ft. per minute.
At N ...	1·55	95	5 ft. 9 in. by 2 ft. 10 in. = 16·30 sq. ft.	1,548
„ ...	2·5	86		1,402
„ ...	2·10	115		1,874
„ ...	2·20	101		1,646
Mean		99	16·30	1,614

HASWELL COLLIERY, MAY 14TH, 1890.

The Main Coal seam at a depth of about 109 fathoms in the Straight-in North Flat has a section varying from 3 feet 6 inches to 4 feet 6 inches, the mean being 4 feet 1 inch. The wide bords and walls are driven from 15 to 20 feet wide, and winning places and stentons are 9 feet wide. The places are usually kirved at the bottom, and not nicked.

Ordinary blasting powder was employed, made up into cartridges in the usual manner, and fired with "straws." The holes were all hand-machine made, with 1¼ inch drills.

The persons present, between the points M and N traversed by the air, in the district during the course of the experiments was:—

Ordinary—	Hewers	12	
	Putters	2	
	Deputy	1	
		—	15
Extra-ordinary—	Officials	12	
	Committee	10	
		—	22
			— 37

Dr. Bedson's observations are recorded in the schedule of experiments.

The chemical assistants were placed at the stations M and N (see Fig. 8, Plate XXXIX.), where the following observations were made:—

At M—Aspirator I. filled from 1·55 to 3·10 p.m.
At N— „ II. „ 1·50 to 3·20 p.m.

Place.	Time.	Barometer.	Thermometer. Wet.	Thermometer. Dry.	Relative Humidity.
	a.m.	Inches.	Degs.	Degs.	
At bank	11·15	29·40	49·5	55·5	65
At bottom of pit ...	11·30	30·20	65·0	68·0	83
	p.m.				
At M...	2·0	—	61·5	62·0	97
„	2·45	—	61·5	62·0	97
At N...	1·30	30·01	60·0	60·5	97
„	2·0	30·01	60·0	60·5	97
„	2·15	30·01	60·5	60·8	97
„	2·30	30·01	60·2	60·5	97
„	2·45	30·02	60·2	60·5	97
„	3·5	30·03	60·5	61·0	97
„	3·20	30·04	60·2	60·7	97

... IN NORTH FLAT, MAY 14TH, 1890.

Place.			Section of Seam.	Kirving.			Shot Hole.		Shot.			Time of Ignition.	Remarks.
Position on Plan.	Description.	Width.		Length.	Depth under.	Height at Fore-side.	Length.	Position in Place.	Length of Cartridge.	Weight of Explosive.	Number.		
		Feet.	Ft. In.	Feet.	Ft. In.	Inches.	Ft. In.		Inches.	Ozs.		P.M.	
A	Bord ...	9	4 0	9	3 6	20	2 9	Right, 6 in. from roof ...	6	4	1	1 45	Fast shot.
							2 9	Left, do. ...	6	4	2	1 55	Do.
							3 0	Right	9	6	6	2 30	Fair shot.
							3 0	Left	6	4	8	2 47	Good shot.
B	Wall ...	16	3 6	16	3 3	15	3 0	Middle	6	4	3	2 5	Do.
							3 0	Left	7	4½	4	2 15	Do.
							3 0	Right	6	4	5	2 20	Do. cylinder I. filled.
C	Bord ...	15	4 0	15	4 0	24	3 1	Middle	6	4	7	2 33	Do. sample *a* taken.
							3 1	Right	*6*	*4*	...	2 42	Flushed shot.
							3 1	Left	6	4	9	2 55	Good shot.
							3 1	Right	6	4	12	3 10	Do. cylinder II. filled
D	Wall ...	16	4 0	*16	3 4	18	3 0	Middle, 6 in. from bottom	8	6	10	3 0	Do.
							3 0	Left, do. ...	8	6	11	3 4	Do.
							3 0	Right, do. ...	8	6	13	3 12	Do.
E	Wall ...	18	4 6	18	3 3	18	3 2	Middle	7½	5	14	3 20	Do. cylinder III. filled.
							3 2	Right	7	4¾	15	3 30	Do. sample *b* taken.
F	Bord ...	18	4 3	18	3 6	14	3 1	Middle	*6*	*4*	...	3 42	Flushed shot.
							3 1	Middle	6	4	16	3 45	Good shot sample *c* taken.
							3 1	Left	7	4¾	17	3 45 to 4 0 o'clock.	Do.
							3 1	Right	7	4¾	18		Do.
G	Wall ...	20	4 3	20	3 3	18	3 0	Middle	6	4	19		Do.
							3 0	Right	8	5¼	20		Do.
							3 0	Left	7	4¾	21		Do.
H	Wall ...	18	4 0	18	3 2	18	3 0	Middle	6	4	22		Do.
							3 0	Right	6	4	23		Do.
							3 0	Left	6	4	24		Do.
								Totals ...	161½	110			

* Kirved at top of seam.

Place.	Time.	Velocity of Air.	Area of Place of Measurement.	Volume of Air.
	p.m.	Feet per Minute.	Square Feet.	Cubic ft. per minute.
At N ...	1·30	160	5 ft. 6 in. by	4,400
„ ...	2·30	193	5 ft. =	5,307
„ ...	3·20	187	27·5 sq. ft.	5,143
Mean		180	27·5	4,950

SOUTH HETTON, JULY 22ND, 1890.

The experiments were conducted in a portion of the same district as that visited by the Committee on November 22nd, 1889, and April 1st, 1890.

The explosives used on this visit were ordinary blasting powder and roburite. Six places were prepared in the district, compressed blasting powder being used in the fourth, fifth, and sixth, and roburite in the remaining three places. All the shots were fired with fuse, and the Bickford igniters and detonators were used in the case of roburite.

The following persons were present between the points M and N_1, and M and N_2 during the course of the experiments:—

		M to N_2.	M to N_1.
Ordinary—	Hewers	... 6	3
	Putters	... 2	1
	Deputies... ...	... 2	2
		— 10	— 6
Extra-ordinary—	Officials	... 5	5
	Committee ...	... 5	5
		— 10	— 10
		— 20	— 16

The observations made by Dr. Bedson are contained in the schedule of experiments.

Dr. Bedson's assistants were stationed at the points M, N_1, and N_2 (see Fig. 7, Plate XXXVIII.). One assistant remained at M during the course of the observations, whilst the second was stationed at N_2 during the course of the experiments with blasting powder, and at N_1 during those with roburite. They made the following observations:—

At M —Aspirator I. was filled from 12·42 to 1·49 p.m.
At N_2 „ II. „ 1·0 „ 1·37 p.m.
At N_1 „ III. „ 2·7 „ 2·45 p.m.

Place.	Time.	Barometer.	Thermometer. Wet.	Thermometer. Dry.	Relative Humidity.
	a.m.	Inches.	Degs.	Degs.	
At bottom of pit ...	11·40	30·56	—	71·0	—
	p.m.				
At M	12·47	—	63·0	64·0	94
„	1·49	—	63·0	64·0	94
At N_2	1·10	30·62	62·5	63·0	97
„	1·35	30·62	63·5	63·5	100
At N_1	2·15	30·59	62·0	62·0	100
„	2·30	30·59	62·5	62·5	100

BLASTING POWDER—

Place. Position on Plan.	Place. Description.	Place. Width.	Section of Seam.	Kirving at Top of Seam. Length.	Kirving at Top of Seam. Depth under.	Kirving at Top of Seam. Height at Foreside.	Shot Hole. Length.	Shot Hole. Position in Place.	Fuse. Length.	Shot. No. of Bobbins.	Shot. Weight of Explosive.	Shot. Number.	Time of Ignition.	Remarks.
		Feet.	Ft. In.	Feet.	Ft. In.	Inches.	Ft. In.		Feet.		Ozs.		P.M.	
D	Wall ...	12	5 0	8	4 0	15	3 6	Left, 14 in. from thill.	4	3	8	1	12 55	Good shot.
							3 6	Right, 18 in. do.	4	3	8	...	1 0	Shot missed.
E	Wall ...	13	5 6	11½	3 0	8	3 6	Mid., 16 in. do.	4	3	8	2	1 10	Shot too light; cylinder IV. filled.
							3 6	Right, do. ...	4	4	10⅔	3	1 20	Fast shot.
F	Wall ...	13	5 6	7½	3 0	10	3 0	Middle, do. ...	4	4	10⅔	4	1 25	Good shot; cylinder II. filled.
							3 0	Left, do. ...	4	3	8	...	1 40	Shot missed.
								Totals ...	24	14	37⅓			

ROBURITE—

A	Bord ...	12	5 4	8	3 0	9	3 0	Middle, 15 in. from thill.	3½	...	6	1	2 5	Heavy shot.
					3 6		3 0	Right, 18 in. do.	3½	...	6	2	2 10	Good shot; cylinder I. filled.
B	Wall ...	11	5 4	11	3 6	5	3 0	Mid., 16 in. do.	3½	...	6	3	2 15	Fair shot.
						8	3 0	Right, 16 in. do.	3½	...	6	4	2 20	Good shot; cylinder III. filled
C	Wall ...	13	5 3	9½	4 0	8	3 6	Mid., 16 in. do.	3½	...	6	5	2 25	Fair shot.
						8	3 6	Right, 16 in. do.	3⅛	...	6	6	2 30	Do.
								Totals ...	21	...	36			

Place.	Time.	Velocity of Air.	Area of Place of Measurement.	Volume of Air.
	p.m.	Feet per minute.	Square feet.	Cubic ft. per minute.
At N_2 ...	1·0	62	4 ft. by 3 ft. = 12 sq. ft.	744
,, ...	1·35	149		1,788
Mean		106	12	1,272
At N_1 ...	2·15	116	5 ft. 4 in. by 3 ft. = 16 sq. ft.	1,856
,, ...	2·20	33		528
Mean		74	16	1,184

ELEMORE COLLIERY, MARCH 5TH, 1891.

These experiments were made with the view of ascertaining the rate of the removal of the fumes, and were conducted in a portion of the same district as that visited on October 24th, 1889, and February 5th, 1890.

The explosive used was roburite, fired under the same conditions as previously.

The following persons are ordinarily employed in this district :—

Hewers	11	
Putters	3	
Deputies	2	
		— 16

During the course of the experiments there were present in the places A and B examined (Fig. 9, Plate XXXIX) :—

Ordinary—	Hewers	2	
	Putter	1	
	Deputy	1	
		—	4
Extra-ordinary—	Officials	8	
	Committee	6	
		—	14
			— 18

The observations made by Dr. Bedson are recorded in the schedule of experiments.

The following observations were also recorded :—

Place.	Time.	Barometer.	Thermometer. Wet.	Thermometer. Dry.	Relative Humidity.
	p.m.	Inches.	Degs.	Degs.	
At bank	12·45	29·73	49·0	54·0	69
,, ...	3·0	29·76	49·0	54·0	69
At bottom of pit ...	12·50	30·34	57·0	66·0	56
,, ,, ...	2·55	30·33	57·0	66·0	56
At M	2·0*	30·34	61·0	62·0	94
,, ...	2·25	30·34	59·0	60·0	94

Place.	Time.	Velocity of Air.	Area of Place of Measurement.	Volume of Air.
	p.m.	Feet per minute.	Square feet.	Cubic ft. per minute.
At M ...	2·5	42	4	168
,, ...	2·15	52	4	208
Mean		47	4	188

* Seventeen persons were ordered into the return air-way, N.

TABLE VII.—EXPERIMENTS WITH ROBURITE AT ELEMORE COLLIERY, IN THE EAST MAIN COAL SEAM, NEW DRIFT WAY, NORTH FLAT, MARCH 5TH, 1891.

PLACE.			Section of Seam.	KIRVING.			SHOT HOLE.		FUSE.	SHOT.			Time of Ignition.	REMARKS.
Position on Plan.	Description.	Width.		Length.	Depth under.	Height at Foreside.	Length.	Position in Place.	Length.	Length of Cartridge.	Weight of Explosive.	Number.		
		Feet.	Ft. In.	Feet.	Ft. In.	Inches.	Ft. In.		Feet.	Inches.	Ozs.		P.M.	
A	Bord ...	12	4 6	12	2 10	24	2 9	Left ...	3	7	4	1	1 40	Fast shot.
							2 9	Right...	3	7	4	2	1 55	Fair shot.
B	Wall ...	7	4 6	7	3 0	24	2 6	Right...	3	7	4	3	2 5	Good shot.
							2 9	Left ...	3	7	4	4	2 10	Do. The hewer began to fill the coals without delay, a light smoke being visible. 2·12, sample *a* taken. 2·16, at this time all smoke was cleared away. 2·17, cylinder I. filled. 2·22, cylinder II. filled; sample *b* taken; sample *c* taken.
								Totals...	12	28	16			

The PRESIDENT said they must all feel obliged to the Durham Coal Owners' Association and the Durham Miners' Association for their permission to have this minute statement respecting the effects of the fumes of roburite, tonite, and gunpowder read before their members. He thought it was a complete answer to the complaints of those who alleged themselves to have suffered from the fumes of these explosives. There was one question he wished to ask Dr. Bedson: How was it, in the examination of the fumes, that only traces of carbon monoxide were found in the return? This occurred in several of the analyses, and seemed somewhat curious, and perhaps the Professor could tell them what became of that which existed in the place at the time of the explosion.

Mr. W. COCHRANE said he would like to ask Professor Bedson—although the conclusions arrived at applied equally to gunpowder—whether in the event of there not being good ventilation after the firing of the shot, the fumes would be injurious. Supposing, for instance, they were exploding in a close drift or the face of a metalliferous vein where the ventilation was deficient, would it be deleterious to health to remain in such an atmosphere?

Mr. HALL (H.M. Inspector of Mines) said he might mention as bearing out the conclusions of the present report, that when these explosives were introduced into Lancashire there was a great outcry against the fumes, and Professor Dixon, of Owen's College, and one of the local doctors reported on the subject. The conclusions they came to were similar to those now arrived at. The outcry was at one particular colliery, he believed, where there was a difficulty between the employers and the men; since that time roburite had been very much used in Lancashire, and they had never had any more complaints as to the effects of the fumes.

Mr. W. N. ATKINSON (H.M. Inspector of Mines) suggested that it would be interesting to know the effects of handling these explosives in the case of wounds, or coming in contact with a scratch or injury.

Mr. T. A. SOUTHERN (late H.M. Inspector of Mines) asked if gunpowder was not capable to some extent of causing blood poisoning, in case of its getting into a wound?

Mr. A. L. STEAVENSON said this was the model of what a paper should be; it was, however, rather too lengthy for discussion that day, and he hoped they would have a further opportunity at the Birmingham meeting, when they would have had time to make their notes upon it, and would be better prepared to discuss it properly. There were one or two points which occurred to him. He thought he was right in saying that the report proved powder to be the worst explosive of all; if that was so, let them remember that the quantity of powder used in the coal mines of Durham was infinitesimal as compared with that used in Cleveland. In one single mine one hundred shots were fired every hour for eight hours, and yet they never heard of any of the men being injured by using this, the very worst explosive the doctors had tested. One question did not appear to be noted in regard to roburite and tonite, and that was the handling of it. The men stated that they had suffered

FIG. 3.

ROBURITE EXPERIMENTS

Elemore, October 24th 1889.

EAST MAIN COAL SEAM.
NEW DRIFT WAY DISTRICT.

Scale 3·256 Chains to 1 Inch

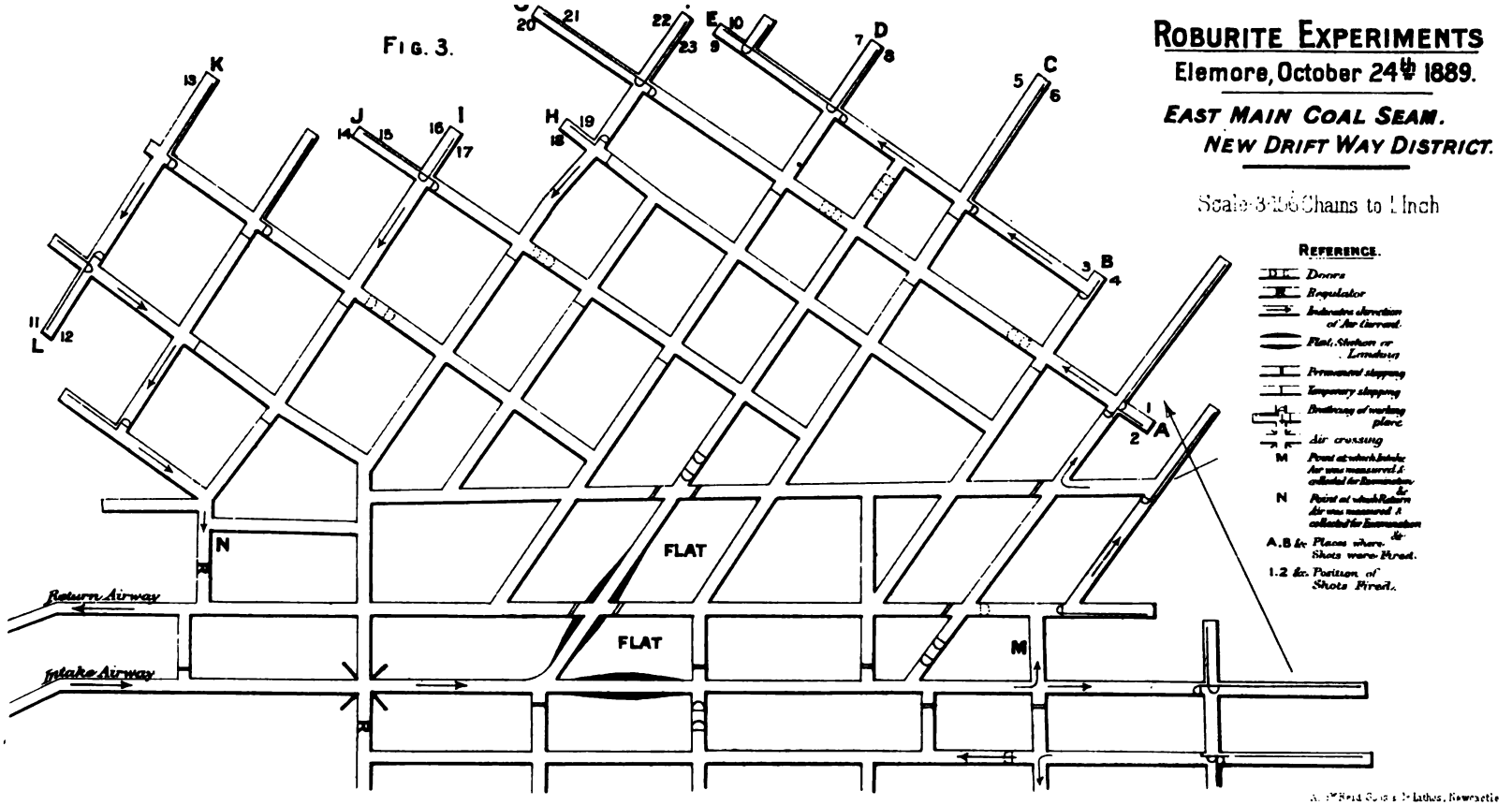
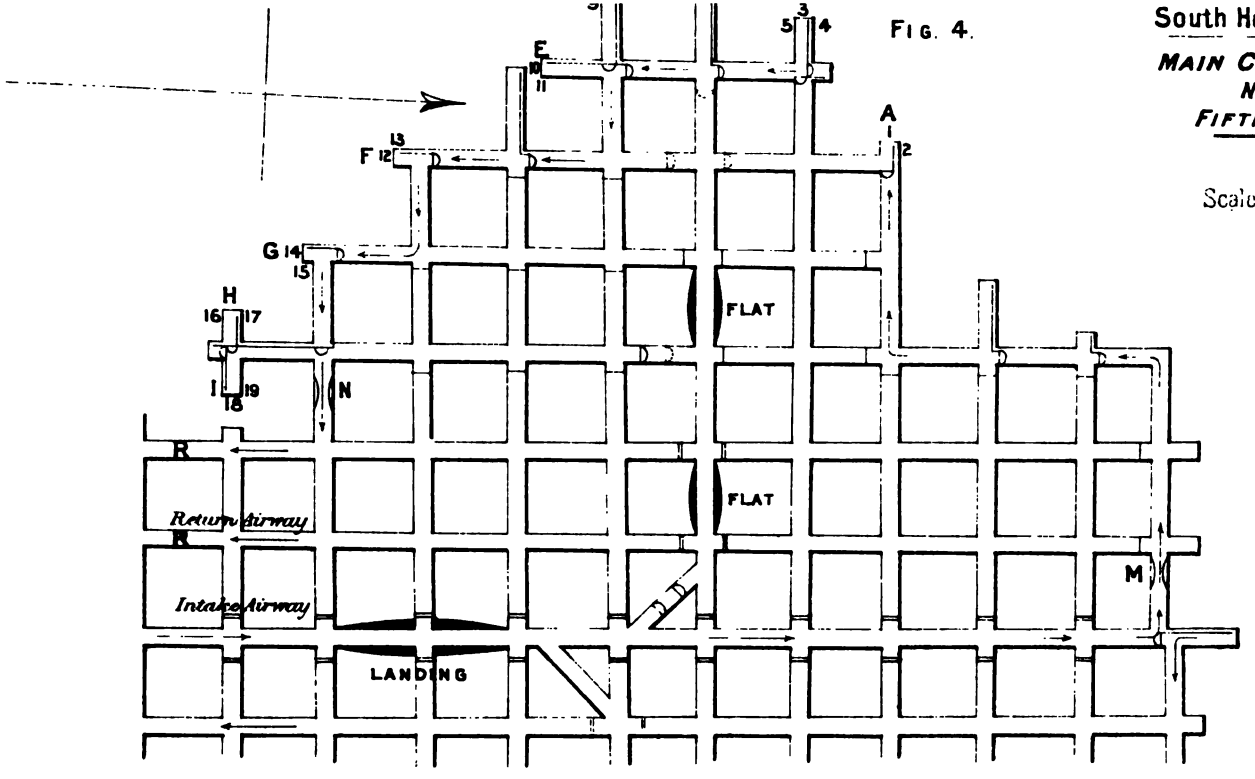


FIG. 4.

South Hetton, Novr 22nd 1889.

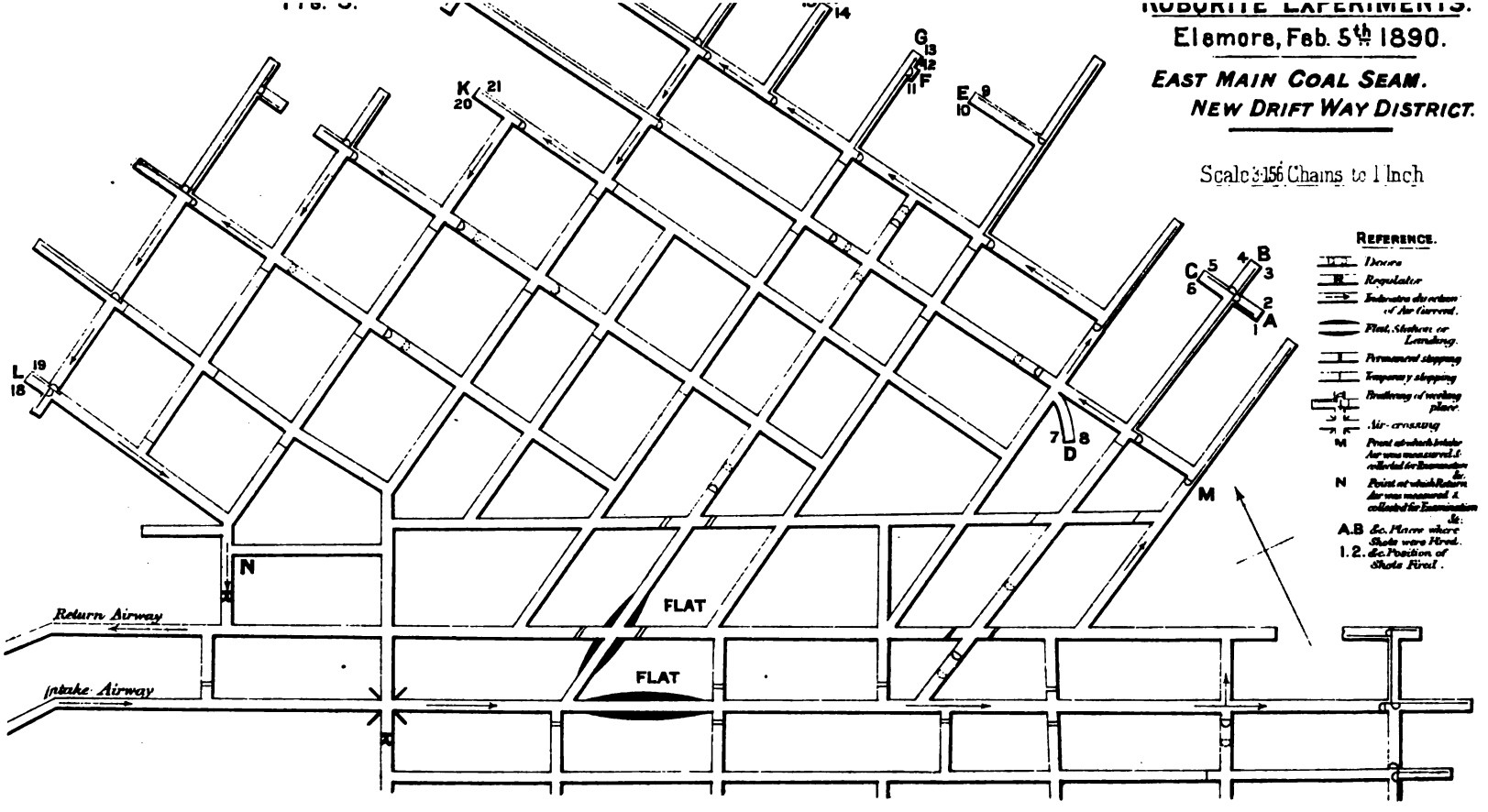
MAIN COAL SEAM.
NORTH EAST BANK
FIFTH WEST FLAT

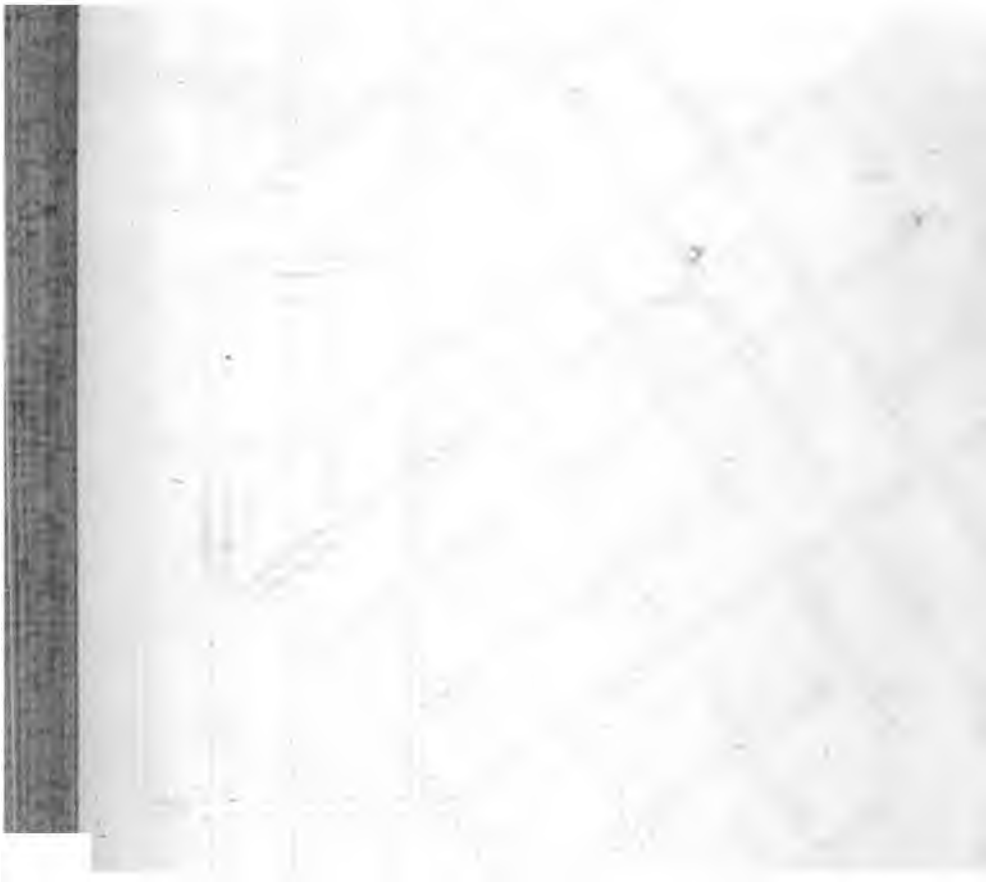
Scale – 4 Chains to 1 Inch



REFERENCE.

Doors
R Regulator
Indicates direction of Air Current
Flat, Shelves or Lowdrag
Permanent stopping
Temporary stopping
Roadway of working place
Air crossing
M Point at which Intake Air was measured & collected for Examination &c
N Point at which Return Air was measured & collected for Examination &c
A.B. &c. Places where Shots were Fired
1.2 &c. Numbers of Shots Fired


ROBURITE EXPERIMENTS.
Elemore, Feb. 5th & 1890.
EAST MAIN COAL SEAM.
NEW DRIFT WAY DISTRICT.
Scale 3.156 Chains to 1 Inch
REFERENCE.
Drivers
Regulator
Indicates direction of Air Current.
Flat, Shaken or Landing.
Permanent stopping
Temporary stopping
Brattice'd working place
Air-crossing
Point at which intake Air was measured & collected for Examination &c.
Point at which Return Air was measured & collected for Examination &c.
A.B &c. Places where Shots were Fired.
1. 2. &c. Position of Shots Fired.
FLAT
FLAT
Return Airway
Intake Airway
N
M
R
L 19 18
K 21 20
G 13 12 11 F
E 9 10
C 5 6
B 4 3
A 2 1
D 7 8



South Hetton, April 1st 1890.

MAIN COAL SEAM
NORTH EAST BANK
FIFTH WEST FLAT.

Scale - 4 Chains to 1 Inch

FIG. 6.

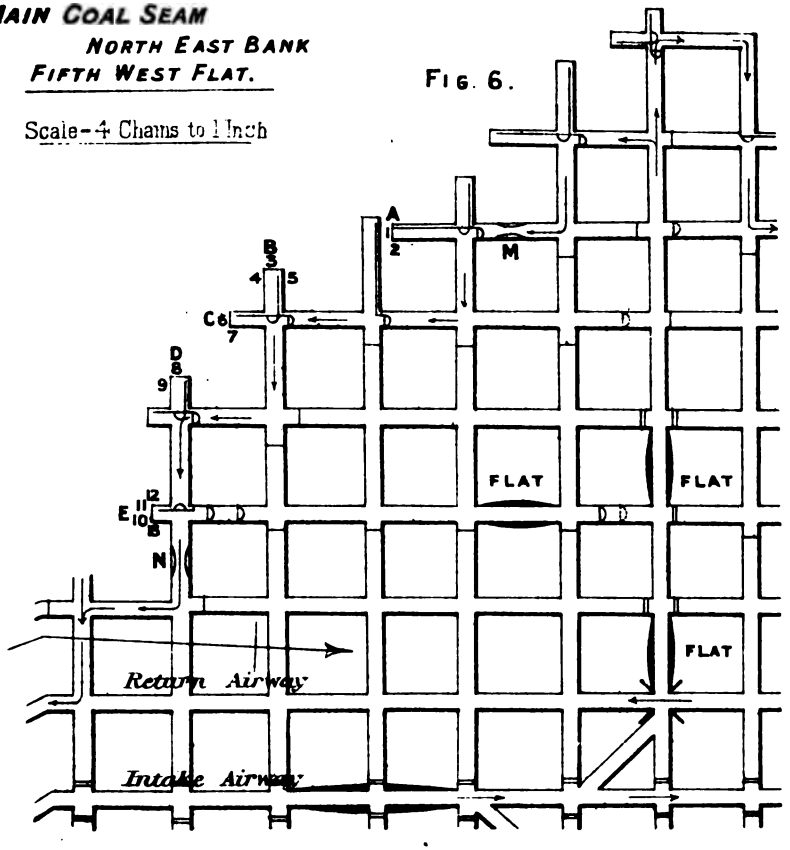
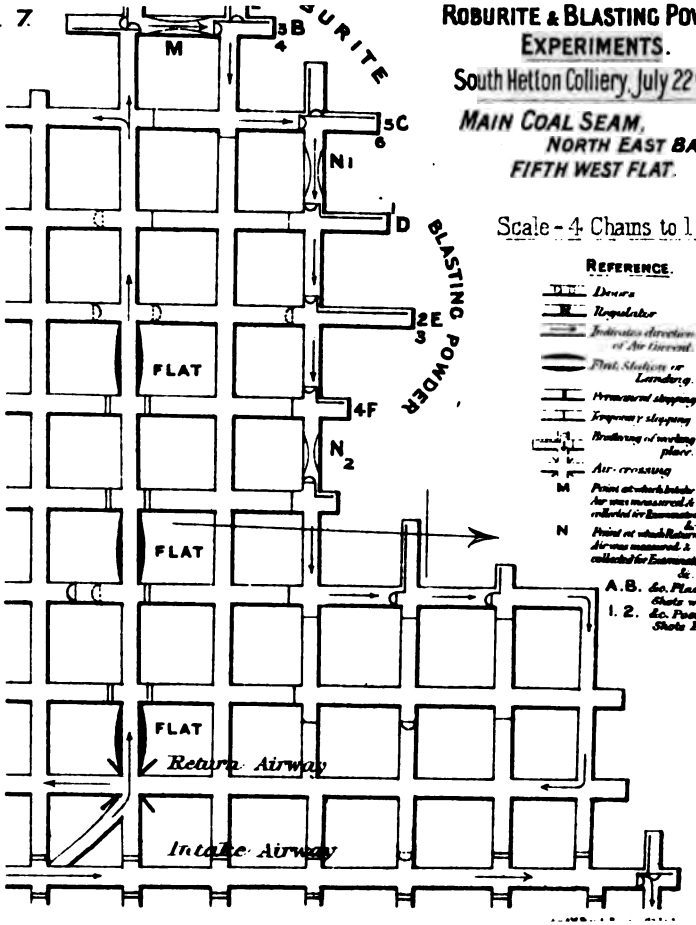


FIG. 7.



ROBURITE & BLASTING POWDER EXPERIMENTS.

South Hetton Colliery, July 22nd 1890.

MAIN COAL SEAM,
NORTH EAST BANK,
FIFTH WEST FLAT.

Scale - 4 Chains to 1 Inch

REFERENCE.

Doors
Regulator
Indicates direction of Air Current.
Print Stations or Landing.
Permanent stopping
Temporary stopping
Widening of working place.
Air-crossing
M Point at which Intake Air was measured & collected for Examination &c.
N Point at which Return Air was measured & collected for Examination &c.
A.B. &c. Places where Shots were Fired.
1. 2. &c. Position of Shots Fired.

To illustrate "An Investigation, as to whether the Fumes produced from the use of Roburite and Tonite in Coal Mines, are injurious to Health."

ROBURITE EXPERIMENTS.

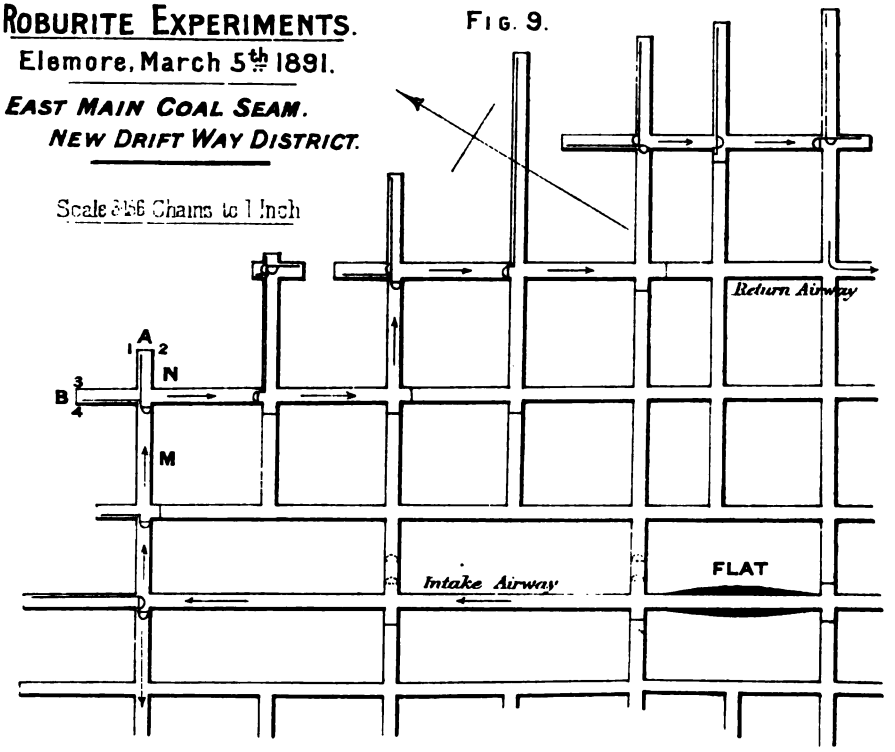
Elsmore, March 5th 1891.

EAST MAIN COAL SEAM.

NEW DRIFT WAY DISTRICT.

Scale 3 6 Chains to 1 Inch

FIG. 9.



REFERENCE.

Doors
Regulator
Indicates direction of Air Current
Brick, Stoppings or Leaderings
Permanent stopping
Temporary stopping
Boarding of working place
Air-crossing

M Point at which Intake Air was measured & collected for Examination &c.

N Point at which Return Air was measured & collected for Examination &c.

A, B &c. Places where Shots were Fired

1, 2 &c. Position of Shots Fired.

BLASTING POWDER EXPERIMENTS.

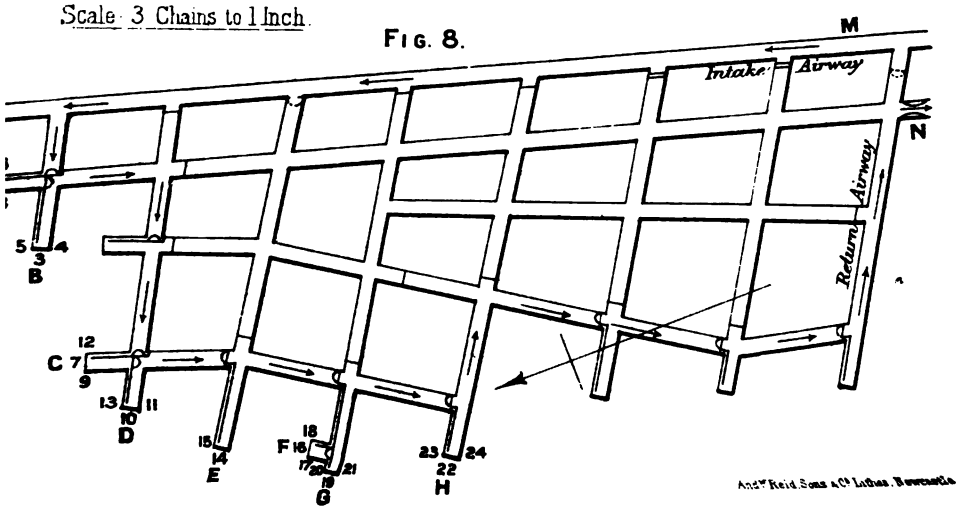
Haswell Colliery, May 14th 1890.

MAIN COAL SEAM,

STRAIGHT-IN NORTH FLAT.

Scale 3 Chains to 1 Inch.

FIG. 8.



And.r Reid, Sons & Co. Lithos, Newcastle.

from a species of blood poisoning, but this was not sufficient proof; he hoped Drs. Hume and Drummond would look into this, and perhaps be able to give the results of their further experience at another meeting. The reference to Tursdale (page 376) was not quite exact, the report stated that "owing to the condition of the district selected it was deemed desirable not to fire shots." As a matter of fact, the Committee were taken to a part of the mine which had not been worked for many years, and it was covered with dust, and so they decided not to fire a shot. He had gone into the question of the amount of ventilation in the Cleveland mines in comparison with the number of men employed, but he was afraid he could not sufficiently trust his memory to give the particulars now; it was, however, certainly stronger and greater than the amount per person employed in the Durham coal mines. At the time the Royal Commission was sitting, in 1864, there was no ventilation by machinery, and the mines were very smoky, the men complained, but without being able to prove very much. But now that they had mechanical ventilation there was no gas to do any harm.

Dr. P. PHILLIPS BEDSON said with regard to the President's question as to the proportion of carbon monoxide found in the return as compared with the place, he would point out that it was less at the return than at the place; one would naturally expect that to be so because it was diluted with the air, so much so perhaps that they might not be able to detect it. With regard to Mr. Cochrane's question, any explosive with which he was familiar would be injurious to a man working in an atmosphere overcharged with the fumes, just the same as in an overcrowded room, or a room overcharged with the products of combustion of coal gas; they all knew the effects of breathing bad air. The percentage present would depend on the amount of the explosive fired; if seven ounces of explosive were fired in 540 cubic feet of air the proportion of carbon monoxide would not be dangerous. The worst results they had obtained in the returns in these experiments were probably better than the state of the air in the gallery of an ordinary theatre. The question of handling these explosives was purely a physiological matter, and did not concern him as a chemist; the medical gentlemen had found no evidence of injury from handling, but probably enquiry as to this would be better made among the workpeople who were engaged in its manufacture, or in preparing the shots. If a man had a cut in his hand it might cause blood poisoning, but otherwise, he thought, there was no danger. Nitrobenzene had been and still was used for scenting soaps. It was possible to produce blood poisoning from gunpowder.

Mr. T. A. SOUTHERN (Derby) said carbon monoxide could not be breathed with impunity even when diluted with air, but the exact amount to produce a deleterious effect in respiration had, so far as he knew, not been determined.

Mr. A. SOPWITH said they would all agree that it was a most instructive and exhaustive enquiry; but he understood that they were indebted to the Durham Coal Owners' Association and Durham Miners' Association for the privilege of having the report read before the Institution and printed in the Transactions. He quite

agreed with Mr. Steavenson that this was specially a paper for their Transactions, and he thought it proved the value of the Federated Institution that so valuable a report could be put in the hands of so many who would not otherwise have had access to it. He begged to move a vote of thanks to the Durham Coal Owners' and Miners' Associations for the permission they had given for it to be printed in the Transactions.

Mr. W. N. ATKINSON seconded the motion, and it was adopted unanimously.

The PRESIDENT said he hoped the discussion would be renewed at their meeting in Birmingham. There were so many things in the paper that they could not at all comprehend by once reading over. On the present occasion, however, the very cordial thanks of the meeting were due to Professor Bedson for the way in which he had conducted these experiments, and brought before them the result of his great work.

Mr. A. SOPWITH seconded the vote of thanks, which was carried unanimously.

Mr. H. HALL (H.M. Inspector of Mines) read the following paper on "Coal-dust":—

COAL-DUST.

By Henry Hall.

Perhaps no subject in connexion with mining has attracted so much attention during the past fifteen years as that of coal-dust. When attention was first directed to its possible dangers, either in conjuction with fire-damp, or *per se*, the views advanced were received almost with ridicule, and by many the "coal-dust theory," as it was called, was looked upon simply as a "red herring" useful only to divert attention from other unpleasant aspects of colliery explosions.

Gradually the dangers of dry coal-dust have received more serious consideration, and now the author ventures to submit that the consensus of opinion among mining authorities is that its dangers are such as demand speedy and energetic treatment.

We are most of us familiar with the results that have been obtained by means of experiment by various commissioners, committees, and individuals to elucidate this subject. Those experiments and results have conclusively shown that wherever dry coal-dust exists in underground workings in such a mechanical condition that its finer particles can be lifted and carried by the air passing along and lodged on the sides and roof or bars of the workings, an explosion of dust, *per se*, or with small admixtures of fire-damp, otherwise harmless, is possible.

The ignition and explosion of dust in the entire absence of fire-damp by gunpowder shots, and by an initiatory explosion of a fixed quantity of fire-damp, have again and again been effected in long galleries prepared for the purpose, and its ignition, when a small and otherwise harmless amount of fire-damp is present, is a certainty at almost every attempt.

The writer, by means of some recent experiments in an actual mine shaft, has endeavoured to remove any doubt that might exist as to the conditions in experimental chambers being the same as those present in the mine itself.

The point which appeared to him to deserve most attention was whether or no an ignition of coal-dust in a "mine-working" could obtain such a ready supply of air as to ensure a sufficiently rapid combustion as would give an explosive effect, or, in other words, whether in a mine the ignition of dust would "carry on" and travel over the whole or greater part of such workings where a supply of dust might be found.

Wherever artificial galleries of any length have been used for experiments, they were open to the objection that valves had to be inserted at intervals to relieve the pressure set up by the explosions for fear of the apparatus being destroyed; and it was just possible that such valves might be the means of supplying more air as the explosion travelled, which would not be forthcoming in an actual mine-working.

It is not necessary to detail here the writer's experiments, because they have already been brought under the notice of most of the members present. The

drawing on the wall is a fair representation of the appearance of the top of the shaft, the result of a gunpowder shot blowing out into air saturated with coal-dust at a depth of 180 yards from the surface.

In very many of the great colliery explosions there has been no decisive evidence accounting for the great violence and damage over such large areas of the mines, scorching flames having passed along great lengths of roads, an effect, which if fire-damp alone were implicated, seems almost impossible; and this in mines where the witnesses were unanimous that the workings were well ventilated, and fire-damp seldom if ever present in any serious quantity. It is, no doubt, natural on the occasion of an explosion in a colliery for the officials to endeavour to show as clean a bill of health as possible, but enquiries into such matters nowadays are close and exhaustive, and yet in many cases to an unprejudiced mind they have been far from convincing as regards the agency which has been at work. It must not for a moment be supposed that the writer wishes to convey the idea that there have been no disastrous explosions from large accumulations of fire-damp; such have, no doubt, occurred from time to time. All mining men are aware that mines are liable from temporary causes to be flooded with fire-damp, any accidental ignition of which would be fatal to the men underground in the colliery, and such accumulations take place most unexpectedly and from sources often the least suspected.

The importance of the phenomena relating to coal-dust consists in the fact that the conditions necessary to cause a disaster may continue to be present when a mine is thoroughly ventilated and free from fire-damp; and when we remember that what is termed "free from fire-damp" only means in practice that the atmosphere of the mine is so diluted that there is no visible evidence of the presence of this dangerous gas, and that some quantity more or less definite according as the seam is fiery or otherwise must inevitably be present, the subject assumes additional importance.

It seems almost remarkable that any doubt should have existed that a material such as coal-dust dispersed in warm air, once ignited, would fail to produce a rushing conflagration. Admitting, then, that this danger exists, the question arises—How may it be met? Can dangerous accumulations of dust be avoided? Up to the present the only means which has attained partial success is the periodical application of water, either by means of sprays emitted through pipes at a high pressure along the roads, or by moving water tanks. The first of these methods promises the most success, and has been largely applied in South Wales and other districts, where its efficiency has been increased by the Martin process of blowing the water by means of compressed air; but this necessarily entails a double system of pipes, and is therefore expensive, and the moving water-tanks, which are not so costly, are objected to on the ground that they cause the floors to lift. Both of these systems fail to produce any appreciable effect at the face of the workings except in warm seams where there may be a reduction of temperature of a few degrees; they both add to the comfort and health of those engaged on the main roads, and must also reduce the amount of traction.

The system of pipes remains much as at first introduced; 2-inch main pipes, and smaller spray pipes with leaden plugs, are usually adopted. The leaden plug is perhaps recent, and enables the amount of spray to be readily manipulated.

Attempts have been made to saturate the air of mines with watery vapour, but without success. The writer is told that even in mills, where the area to be dealt with is much more limited, the saturation can only be effected up to a distance of a few yards from the source, and appears to be quite mechanical.

Iron or steel trams, and where wood is used, tongued and grooved boards, are effective to considerably reduce the amount of dust on the roads. The writer has been told that the change from plain boards to tongued and grooved reduced the dust to less than one-fourth of what it had been. Something can also be done by well watering the trams of coal before they are sent out, either by passing them under sprays or by means of watering cans. No serious attempt appears to have been made to deal with the dust systematically at the face of each working place—a course which would perhaps be the most natural one to adopt; but the writer has seen a longwall face dealt with by means of tanks of water and hand watering cans, the collier in each working being required to apply the water at intervals during the day, and the effect was considerable in allaying the dust and making the places more pleasant to live in; but the universal adoption of such a method would entail great expense and constant supervision.

Whether the dusts of different coal seams, when present in a similar mechanical condition as to fineness, are all equally dangerous, has not as yet been proved. It is possible that the danger may arise from the chemical constituents of the dust, and possibly, as pointed out by the Messrs. Atkinson, one mine might differ from another, or its chemical character may vary in the same seam, accordingly as the dust had been exposed a long or a short period to the influence of the atmosphere. The writer has collected samples of the lighter dust from the timbers of main roads, and also of that freshly wrought, and has had them analysed, with the following results:—

"Wigan, 27th May, 1891.

"Dear Sir,—The following are the results of analysis of the two samples of coal-dust received from you last week.

"As received, and without any drying, they gave:—

	No. 1. Per Cent.		No. 2. Per Cent.
Volatile matter	19·75	...	18·16
Fixed carbon	70·85	...	60·25
Ash	6·40	...	14·93
Sulphur	1·45	...	1·13
Water	1·55	...	5·53
	100·00		100·00

Both samples yield a very low percentage of volatile matter, which has scarcely any illuminating power, and their coking properties are almost *nil.* Both these effects are such as might be expected in coal which has been exposed to the atmosphere for some considerable time. In No. 2 the amount of water is much greater than in No. 1, as also the amount of ash, which is very high. Reckoning as combustible the volatile matter, fixed carbon, and sulphur, it will be seen that whilst No. 1 contained 92·05 per cent., No. 2 only contained 79·54 per cent. After drying at 212 degs. Fahr. the samples gave the following ultimate analyses :—

	No. 1. Per Cent.	No. 2. Per Cent.
Carbon	80·04	69·64
Hydrogen	4·04	3·17
Oxygen	6·87	9·34
Nitrogen	1·08	0·86
Sulphur	1·47	1·19
Ash	6·50	15·80
	100·00	100·00

"No. 2 contains considerably more oxygen than No. 1, and if we deduct the ash the disproportion will be greater; as in No. 1 it will be 7·34 per cent. of the remaining constituents, while in No. 2 it is 11·09.

Yours faithfully,

Henry Hall, Esq.,
H.M. Inspector of Mines,
Rainhill.

RALPH BETLEY.

"N.B.—No. 1 Sample was collected from the screens above ground, and was freshly wrought. No. 2 was collected from the timbers underground, and had been a long time exposed to the atmosphere of the mine."

It is always much more easily practicable to accomplish an end when that end can be achieved by the discontinuance of an existing practice than is the case when additional duties are sought to be enforced, and the writer would submit that in dry, deep, and warm mines legislation requiring the workings to be constantly kept clear of accumulations of dust would be much more onerous and expensive than the compulsory abandonment of dangerous explosives.

If we elect to adopt "the abandonment of dangerous explosives," as being the most advantageous and most likely course to secure the object in view, viz., the reduction of disastrous colliery explosions to the utmost possible minimum, then it will be necessary to decide which of the various explosives possess features promising the greatest security. The writer has carried out a great number of experiments with different explosives, the most recent of which are here appended :—

Details of Experiments with various Explosives fired into Air saturated with Coal-Dust.

Series No. 1.—Without Tamping.

Nature of Explosive.	Quantity of Explosive.	Nature of Tamping.	Quality of Dust in Suspension.	Temperature before Firing.		Result.
	Ounces.					
Gunpowder (ordinary)	4	None.	None.	47	54	Flame, 5 feet.
Roburite ...	4	Do.	Do.	47	55	No flame visible.
Gelignite ...	4	Do.	Do.	47	55	Flame, 5¼ feet.
Securite ...	4	Do.	Do.	46	54	Flame, 4½ feet.
Tonite ...	4	Do.	Do.	46	53	Flame, 5¾ feet.
Series No. 2.—Coal-Dust Tamping.						
Gunpowder	4	5 in. of 6-ft. seam dust.	6-feet seam.	46	53	Flame, 5 feet.
Roburite ...	4	Do.	Do.	47	54	No flame visible.
Gelignite ...	4	Do.	Do.	47	53	Flame, 6 feet.
Securite ...	4	Do.	Do.	47	55	Flame, 8½ feet; dust ignited.
Tonite ...	4	Do.	Do.	48	56	Flame, 4½ feet.
Tonite ...	4	Do.	Do.	...	...	Flame, 5½ feet.
Series No. 3.—Clay Tamping.						
Gunpowder	4	5 in. dry clay.	6-feet seam.	49	54	Flame, 7½ feet; dust ignited.
Roburite ...	4	Do.	Do.	50	56	No flame visible.
Gelignite ...	4	Do.	Do.	49	55	No flame visible.
Securite ...	4	Do.	Do.	48	58	Flame, 6½ feet.
Tonite ...	4	Do.	Do.	49	58	No flame visible.
Roburite ...	4	None.	...	47	56	No flame visible.

In these experiments the cannon, formed out of a solid steel ingot, was fired at the bottom of a small vertical boiler, with the upper end cut away. The dust was riddled down from the top immediately before firing each shot.

The value of these experiments is detracted from in consequence of the mouth of the cannon being 3 feet below the line of sight, so that it is quite possible there may have been flame in some instances below this level. Roburite shows the best record.

In the next series of experiments the cannon was arranged so that its mouth was visible, and carbonite was included in the list of explosives :—

SERIES No. 1.—WITHOUT TAMPING OR DUST IN SUSPENSION.

Nature of Explosive.	Quantity of Explosive.	Nature of Tamping.	Quality of Dust in Suspension.	Result.
	Ounces.			
Gelignite	4	None.	None.	Flame, 5 feet.
Tonite	4	Do.	Do.	Flame, 6 feet.
Gunpowder, compressed	6	Do.	Do.	Flame, 6 feet.
Securite	4	Do.	Do.	Flame, 4½ feet.
Roburite	4	Do.	Do.	Flame, 3 feet.
Carbonite	5	Do.	Do.	Flame, 2 feet.

SERIES No. 2.—COAL-DUST TAMPING AND DUST IN SUSPENSION.

Gelignite	4	Bullhurst seam dust, 5 inches.	Bullhurst seam.	Flame, 7 feet.
Tonite	4	Trench compound, 4 inches.	Do.	Flame, 2½ feet.
Gunpowder, compressed	6	Bullhurst seam dust, 5 inches.	Do.	Flame, 8 feet.
Securite	4	Do.	Do.	Flame, 7 feet; dust ignited.
Roburite	4	Do.	Do.	No flame.
Carbonite	5	Do.	Do.	No flame.

SERIES No. 3.—CLAY TAMPING AND DUST IN SUSPENSION.

Gelignite	4	Clay tamping, 5 in.	Wigan, 6 ft.	No flame.
Tonite	4	Trench compound, 4 inches.	Do.	No flame.
Gunpowder, compressed	6	Clay tamping, 5 in.	Do.	Flame, 6 feet.
Securite	4	Do.	Do.	Flame, 4½ feet.
Roburite	4	Do.	Do.	No flame.
Carbonite	5	Do.	Do.	No flame.
Roburite	4	None.	Do.	No flame.
Carbonite	5	Do.	Do.	No flame.
Gunpowder, compressed	6	Do.	Do.	Flame, 8 feet; dust ignited.
Tonite	4	Do.	Do.	Flame, 5 feet.

Roburite and carbonite have the best record in this series, but it will be noticed that when the explosives are fired without tamping they are none of them flameless. It should also be noted that the gases resulting from the explosion of some of the explosives under examination are inflammable, whilst in others they appear to be non-inflammable. How far this circumstance may affect their security is not easy to determine.

None of these explosives, therefore, present absolute security; for it seems clear that with the best of them feeders of fire-damp in the drill hole in contact with the body of the charge might become ignited and lead to danger, but some are much more promising than others and far surpass ordinary gunpowder, which is still so universally used for underground operations.

It is a difficult position, but it is quite clear that those explosives which, although tamped with clay, give off flame on blowing out must be discarded altogether, and we then have to decide whether any and what precautions are necessary in the use of those of the safer character.

It will be well to state fairly the conditions under which blasting has to be done. May we assume that in many mines 10 per cent. of the shots are fired in the presence of gas, either in the shape of small blowers or small accumulations, and in some instances in a body of air fouled to the extent of a quarter or half an inch of cap. Exception may be taken to this, but the writer makes the statement as a fair conclusion drawn from an extensive experience. To this danger must be added the presence of dry dust, which as has already been pointed out, it is almost impossible to avoid, though it may be very considerably mitigated by the application of water. Have we any explosive which ensures absolute safety under the above conditions? Those who adopt a high standard of safety will answer this question with a negative.

The writer then submits, finally, that the dangers of dust and gas combined cannot be altogether neutralized by any known process of damping, although they may be greatly diminished—that we possess no explosive absolutely safe under the ordinary conditions of fiery mines—and that the best precautionary measure still remains, as it has hitherto been, to confine blasting operations to such times as the workmen are out of the mines.

Whether or no the coal-dust theory may be accepted in its entirety, that is in the absence of all fire-damp, few of us will be prepared to deny the serious danger of dust in conjunction with partial fouling of the atmosphere of mines by the constant emission of fire-damp, which goes on from day to day, and which being unseen is seldom sufficiently appreciated. And really this is the most important aspect of the question. It is immaterial whether we prove coal-dust to be explosive *per se*, so long as it is acknowledged to be so with imperceptible quantities of fire-damp, because this condition is normal over large areas in most mines.

Those who are of opinion that colliery explosions are due to fire-damp alone, might possibly strengthen their position by undertaking a series of experiments to prove whether large effects can be produced by the explosion of comparatively small quantities of fire-damp mixtures *per se*. This is another phase of the question which it would be well worth while to try to elucidate. Old men who worked in shallow damp mines many years ago tell us that considerable bodies of gas were purposely ignited to save the trouble of bratticing, and that the explosions resulting were quite local and harmless.

The PRESIDENT said that in the first explosion he had to do with he found charred coal-dust sticking to the wagons and props, and they were able to trace the source of the explosion. There were many methods of watering the dust, but it could only obviate the danger where the explosion was caused by the dust taking fire. The firing of the dust would very often explain the explosions which took place almost simultaneously in different parts of the mine, although the ventilation might be quite separate, and the places widely apart.

Mr. N. R. GRIFFITH (Wrexham) said he had listened with great interest to Mr. Hall's able paper, as he also did to a paper on the same subject which that gentleman read in the same room fifteen years ago relating to an explosion which took place at a colliery with which he (Mr. Griffith) was well acquainted and which explosion appeared to have been one of coal-dust ignited by a blown-out shot of gunpowder. He rather differed with the author on one point in the paper he had just read. Mr. Hall told them that none of the explosives he mentioned was absolutely flameless under all circumstances, and he, therefore, thought it possible if gas was given off by a blower at the back end of the hole that any of them might possibly ignite such a feeder of gas. Mr. Hall stated that roburite had never been seen to give flame when fired in a hole which had been properly stemmed, and yet, even when that explosive was used, he thought it possible to ignite gas at the back end of the hole. He (Mr. Griffith) did not think so, if the explosive used was one which, when fired in a tamped hole, gave no flame outside the hole, because if there was no air in the hole the feeder of gas would not ignite in the hole, and with a feeder of gas at the back of the hole there would be no air in the hole, as the gas would drive the air out of the hole. He considered that the feeder of gas could not be ignited in the absence of oxygen; and that probably before the explosion got to the mouth of the hole the explosive would be flameless and could not ignite gas.

Dr. BEDSON said of course they all knew that if they introduced a flame into a combustible gas they would not get any ignition except where it came in contact with air; but, at the same time, they must remember that the feeders of gas referred to were not essentially and necessarily marsh gas, they contained other gases. They might have air; oxygen and nitrogen might be associated with marsh gas in such a feeder. That was the conclusion he would arrive at from the examination of samples of fire-damp collected in mines. Of course, the composition of fire-damp varied considerably under different circumstances. There was one matter referred to in Mr. Hall's paper, and that was with regard to the difference in the composition of the two classes of coal-dust. It was well known that coal itself is a very easily oxidizable material, and undergoes chemical change on exposure to the air, and the new coal-dust and the old coal-dust referred to would naturally have very different compositions. The oxygen of the air, acting upon certain resinous substances in the coal, would remove hydrogen in the form of water, and a portion of the carbon in the form of carbon-dioxide, and a certain proportion would be

oxidized. The rate of this oxidation was increased by a rise in temperature, as was shown in some experiments he had made some years ago* on coal-dust from Ryhope Colliery in connexion with the explosion of an air-receiver at that colliery. He then found that by exposing coal-dust to air at a temperature of 140 degrees centigrade was sufficient to bring about so rapid an oxidation of the dust, causing it to take fire and burn. He would like to be able to answer the question—What was it that made one coal-dust more inflammable than another? He had been engaged for some years in investigating this subject, and had, a few years ago, read a short notice on the subject of coal-dust.† He believed that no ultimate analysis would give any clue, although approximate analysis might, as to why one variety of coal-dust was inflammable and another was not. The only clue they could get was by careful examination of the gases enclosed in the coal-dust; that was the method he adopted in the experiments referred to, and in his paper he had described the results obtained by extracting the gases from the coal-dust under reduced pressure and at high temperatures varying from 50 to 100 degrees centigrade. Those experiments were being continued, and he hoped before long to have material for another paper which he would be able to lay before this Institution. He had obtained from Ryhope Colliery a variety of coal-dust which Mr. W. F. Hall said, from his experience at the screens, was inflammable. From this sample he obtained a volume of gases containing hydro-carbons which were not marsh gas, but evidently mixtures of marsh gas and other higher hydro-carbons. If they could prove the existence of such hydro-carbons, he thought they would be able to form some idea of the source of the inflammability of some coal-dusts. By examining coal-dust in this way they might be able to distinguish one variety from another.

Mr. W. N. ATKINSON said it would add to the value of Mr. Hall's experiments if that gentleman could give them a little fuller information as to the conditions under which the experiments were made. The quantity of coal-dust was given in hundredweights; was any means taken to ascertain whether the whole of the dust was in suspension in the shaft at the time the shot was fired? In the case of continued experiments it was necessary that the dust which remained from the previous experiments should be taken into consideration. In the case of one experiment it was stated that the cannon was fired twenty minutes after the dust had been thrown down the shaft; did that mean that the dust was simply dropped down the shaft and allowed to settle? and was there any dust in suspension or deposited in the shaft itself in that experiment and in the other experiments? This appeared to have a direct bearing on one of the most important points in the coal-dust question, that is: the distance traversed by the flames after the supply of dust ceased. There was another point respecting the proportion of dust used. He (Mr. Atkinson) had worked out the number of cubic feet of air per pound of dust in some of these experiments on

* Transactions of the North of England Institute of Mining and Mechanical Engineers, Vol. xxxvii., page 205.

† Transactions of the North of England Institute of Mining and Mechanical Engineers, Vol. xxxvii., page 245.

the assumption that the whole of the dust was suspended in the shaft; the figures varied from 17 to 97 cubic feet of air per pound of dust, in the cases where the flame appeared at the top of the shaft. In the experiments in the 18-feet shaft, where there was no emission of flame, the proportion was 170 cubic feet of air per pound of dust. Was it not possible that no ignition took place in these experiments owing to the amount of dust used being insufficient? He had a rather strong belief that the main element in the inflammability of coal-dust was its mechanical condition rather than its chemical composition. The old dust he took to be the dust which was borne by the air, and deposited on the timbers and on the roadways. That dust was the finest dust it was possible to get in a pit, and it was on the haulage roads where that dust collected in the greatest abundance that the greatest damage or the greatest evidence of force was found, especially in the case of collieries where the main intake air-ways were used as haulage roads, as in the County of Durham. Mr. Hall seemed to think that the difficulties in the way of watering or damping the dust were so great that the miner must abandon blasting with anything which under any possible conditions would cause an explosion, and that it was not necessary for practical purposes to assume that an explosion might be caused in the entire absence of fire-damp. Now, he (Mr. Atkinson) did not think that was the best way of looking at the question; it must be remembered that shot firing was not the only method by which an explosion could be originated; it was perhaps not the most usual one; so that to confine attention to the question of blasting only was to deal with only part of the case. Explosions were caused by defective lamps; by underground fires; by gob-fires; possibly by sparks; so that to confine attention to blasting would not remove the difficulty. There was another point with regard to water in cases where the difficulties might be so great that to water the whole of the pit or district might be out of the question, it might be possible to water sections of the road, or to remove the dust from sections of the road so as to confine the explosion, when it did begin, to the district of the pit in which it originated, instead of allowing it to travel over the whole of the pit. If such a thing was practicable and had been in operation in several of the greatest explosions he had known particularly, it would undoubtedly have saved the largest proportion of the lives which were lost—and in some cases he had not the slightest doubt lives were saved by the mere fact that certain portions of the road were either wet or the dust on them was so impaired as to be incapable of transmitting the fire.

Mr. W. C. BLACKETT said he would like to point out that if the quantity of air in an open shaft, such as Mr. Hall had experimented with, was sufficient to cause a violent explosion, the explosion would be much more violent, one would expect, if there were more air which was not so free to leave the source of explosion; in other words if they had, instead of the open and short shaft, a long series of galleries through which the flames had to pass, the air—moving in front of the explosion, owing to the natural laws governing moving air—would become compressed, owing to the friction in front, and in that way they would expect to have, as the explosion progressed, a greater violence developed, owing

to the more intimate mixture of dust with air, due to the compression of the air. Those who had been fortunate enough to see the results of an explosion in a mine would have noticed that the further they got from the seat of the explosion the greater the violence appeared. He would, with all due deference, submit to Mr. Hall the advisability in future experiments of covering in the top of the shaft, and if an opening was desired he might effect something equal to what was a long passage in a mine, by what might be called "an equivalent orifice." It also occurred to him that by considering what was going before an explosion—the moving air in front of an explosion—they might also have some means of explaining why an explosion generally confined itself to one air-way; that being the most straight and direct for the dynamical force of the explosion. Thus, if they had two equally dusty roads, one branching off at right angles, the most natural thing would be to expect the explosion to be carried with the most force in a straight road, and not pass to the equally dusty road to the right or left as the case might be, because the path had been prepared for it by the violence of the on-rushing air stirring up the dust Then, as regards the presence of oxygen in the dust, it occurred to him (Mr Blackett) that there might be more than mere chemistry in the matter; perhaps Professor Bedson would be able to consider the point. Charcoal took up a large proportion of various gases owing to its structure, and if they could imagine the fine dust lying upon the timber and other places in a manner peculiar to itself, building up structures favourable to the absorption of oxygen and other gases from the air and favourable to combustion, they would have a reason why the explosion could take place more easily from the coal-dust left untouched in the mine, than what took place from it when collected for experiment and the structure destroyed in the act of collection. As to watering, Mr. Hall preferred watering by pipes to any means of watering by conveyance. He (Mr. Blackett) had some recollection of a paper read by Mr. T. O. Robson,* in which the use of a tub filled with water was advocated, the water leaving the tub through a hole at the end of which was a revolving brush, so that in running along the roadways the revolving brush threw off the water in a fine spray to every part of the gallery—top, sides, and bottom. In that way Mr. Hall's objection to over watering would be removed. As to explosives, he had had the advantage of being present at Washington when Mr. Foggin made some experiments, and these experiments confirmed Mr. Hall's results. They were fired with this difference however: that gas was used as well as coal-dust, and the experiments all pointed to the fact that no explosive at present on the market was safe when detonated unstemmed. He had arrived at the conclusion that the length of the stemming which destroyed the flame of the explosive formed a fair guide in inverse ratio to the safety of the explosive. One "safety" explosive became safe with one inch of stemming, another with two, and some were actually not safe with sixteen inches.

* Transactions of the North of England Institute of Mining and Mechanical Engineers, Vol. xxxvi., page 99.

Mr. A. L. STEAVENSON said he did not like to express an opinion before Mr. Hall, but there was one point not recognized: the exceeding fineness of the dust in question. The dust which explodes is so fine that it floats in the air like a fog; it was not like the ordinary dust of the face. If they had an explosion at the face he would take it to be from gas, but the wagonways were free from gas, and it was here that the very finest of fine dust escaped from the tubs as they went out-bye to the shaft. If a drop of ink was put into a glass of water it spread itself through the whole of the water, and in the same way if they had very fine dust in the air, it permeated the whole of the air; and if they set it on fire they immediately got not only the gas of the coal itself but the action of exceedingly fine dust conveying it from one particle to another. If a shot was fired in a wagonway they had to contend with the dust lying on the timbers and on the sides and roof. He had noticed, particularly in the case of the Tudhoe explosion, where he had made an examination immediately afterwards, that they could trace the explosion along the wagonway in all directions, but directly it got near the face it ceased. He thought this met one of Mr. Hall's fears as to the use of explosives at the face. He believed that the Messrs. Atkinson noticed this in their excellent book published about five years ago. What he wanted principally to enforce now was that they need not be afraid of a coal-dust explosion in the face; if they got an explosion then, it was certainly from gas. He examined the Hetton Colliery thirty years ago, after the explosion. It certainly began in the flue between the boilers and the upcast; a damper had been closed, and when it was raised again the carbonic oxide took fire behind it; it got out to the wagonways among the dust when the explosion immediately went in all directions, and played great havoc. Undoubtedly it resulted in the main from coal-dust; they did not recognize it at the time, nor did they at Tudhoe. It was only afterwards when the Messrs. Atkinson and others impressed upon them that it was the dust, and they began to see that there was no possibility of its being gas. Some gentlemen stuck to the idea that there must be gas, but they would at once see from Mr. Hall's experiments in the shaft that an explosion would occur from dust, and dust alone. He had tried many explosives, in even a simpler manner than Mr. Hall's, by boring holes straight into the face of a quarry, and, going in the dark, had fired an artificially blown-out shot, and by this means he tested whether there were any flames. He did not trust to one hole, but made many, and everyone gave more or less flame. Powder, of course, was the worst of all, for in the case of powder they had the fact that with the blown-out shot were little pellets of burning powder, which would carry fire twenty yards or more. He remembered that a man was so severely burned at Tursdale fifteen years ago by the explosion of a shot that he died. The deputy had examined the place and there was no gas there, but there was an iron tub standing opposite the face, and on the sides of the tub afterwards were blue marks, showing where the burning pellets of powder had struck it. With respect to gas, he might mention that in every ton of coal there was 10,000 feet of

gas, and when they began to set the coal-dust on fire they had the gas of the dust itself—coal gas, not pit gas. They could see this by examining the sides and roof of a road after an explosion, and they would see them covered with coke—the gas had gone. The gas of the dust had been burned, but not the dust itself; this remained as coke on the sides and other places.

Mr. R. L. WEEKS (Durham) said he would like to ask the question:—Was there any violence exhibited at the top of the shaft, and did it do much damage there? There had been an inflammation of dust in a closed coal hopper at Brancepeth C Pit, and it really caused no damage; that is, there was no great violence, although several men were burned and three of them died. The glass in the roof of the coal hopper was cracked with the heat, but there was no violence.

Mr. T. A. SOUTHERN (Derby) said they must look upon these cases, as Mr. Blackett had suggested, in the same way as they would compare the discharge of a small quantity of gunpowder in the open air, with the effects it would produce if discharged in a gun-barrel. As something had been said with regard to explosives, he would like to add that whilst he was an inspector of mines in the Midland district he had to enquire into a case where a small feeder of gas was undoubtedly ignited by a charge of roburite, which had undoubtedly been properly tamped The shot was fired with a fuse, ignited by a hot wire; and it was contended by the representative of the Roburite Company that the gas was probably ignited by the flame of the fuse. After careful examination of the case he (Mr. Southern) formed the opinion that the gas was ignited by the flame of the roburite shot having come in contact with a feeder of gas through an open break from the portion of the shot-hole in which the roburite charge was placed. One thing he would like to suggest was, as to whether sufficient attention had been devoted to the question of removing the dust as distinguished from watering it. He was not aware that any observations had been made to ascertain the quantity of dust which would accumulate on the timbers and sides of a main hauling road in a given time, say, three or six months, and he suggested that such information would be a valuable addition to their knowledge of this subject. He would suggest that it might be practicable to remove the dust periodically from all the main haulage roads —which were generally accepted to be the most dangerous points of a mine with regard to coal-dust—in preference to watering it, and it might also be more efficient.

Mr. M. WALTON BROWN emphasized what Mr. Weeks had said with regard to the ignition of dust at Brancepeth. The hopper was not damaged in any way; the glass of the roof was fitted like a greenhouse, and the greater part of it was starred by the heat but not a single piece had dropped out, and there was no doubt that if there had been the slightest violence it would all have been thrown out. Mr. Hall was of opinion that the use of watering pipes for laying the dust was preferable to moving tanks. He (Mr. Brown) had seen one of these tanks in use at Redheugh Colliery,* and having with him at the time wet and dry bulb thermometers he

* Transactions North of England Institute of Mining and Mechanical Engineers, Vol. xxxvi., page 59.

tested the air before and after using the sprayer. The air was saturated with moisture, and, in addition to that, the whole of the dust from end to end was damped with the sprayer. He had had an opportunity of seeing the place after the sprayer had been in use, and the slight damping had no effect on the floor or the roof. The water laid the coal-dust, but did not affect the roof or bottom. He would make a few remarks respecting certain of Mr. Hall's experiments, which he briefly referred to in his paper. The flame is reported to have reached the top of the shaft in three out of six trials at the White Moss Colliery; that is, the flame extended a vertical distance of about 60 yards from the shot, whereas in a colliery explosion the effects were felt more or less at very much greater distances horizontally. It only appeared in three cases at the surface in the White Moss experiments with charges of 1 lb. of powder; in two cases the dust was not ignited, and in the other the dust was ignited, but the flame did not reach the top of the shaft. In the second series of trials, made by Mr. Hall at the Southport Pit of the Haydock Collieries, in a sinking shaft 130 yards deep, connected with an adjacent sinking shaft by a short drift in a coal seam at a depth of 100 yards, where the cannon was placed upon a scaffold, six experiments were made in this shaft with charges of from 1 lb. to 1½ lbs. of powder, and the coal was not ignited in any case. A third series of experiments were made at the Big Lady Pit of the same collieries; this pit is 210 yards deep, in which a scaffold, placed at a depth of 180 yards, supported two cannons. The downcast (a pumping) shaft was 21 yards distant and connected thereto by two small drifts at depths of 180 and 210 yards respectively. Three sets of experiments were made at this shaft. In the first set, out of five pairs of shots, in which from 2 lbs. to 3 lbs. of powder were fired, in three cases the coal-dust was ignited, and in two cases the flames appeared at the surface. There were six pairs of shots in the second set of experiments, in each of which 3 lbs. of powder were used; there were two cases in which the ignited dust did not appear on the surface; but in the third case the flames reached the surface. In the last set of seven experiments, in which from 3 lbs. to 4 lbs. of powder were used, the dust was ignited in two instances; in the first the flame did not reach the surface, but in the second, in which 6 cwts. of coal-dust were used, the flame and smoke issued from the shaft for five or six seconds. These results could be summarized by stating that the coal-dust was ignited by heavy charges of blasting powder in twelve out of thirty experiments, and that the flame only appeared at the surface in six trials. In three cases the flame traversed a vertical height of 180 yards in a shaft of 8 feet diameter, and in three cases in a shaft of 7 feet diameter it attained a height of 60 yards—that is, adding to the depth of the shaft the height at which the flame appeared above the surface. These experiments simply confirmed what Messrs. Mallard and Le Chatelier said years ago in regard to similar experiments, viz., (1) "that the combustion of coal-dust is not an explosion, and such combustion only produces in the case of most dusts unimportant mechanical effects which are always inferior to those of gas explosions, even in the case of the most inflammable dusts;" (2) "that

the combustion does not extend over the whole area covered with dust"—that, of course, was shown in Mr. Hall's experiments by the flame not coming to the surface, in the case of a shaft only 50 yards deep—also (3) "that the length of dust ignited in a mine is proportional to the intensity of the mechanical action which raised and ignited the dusts"—this was proved by Mr. Hall's experiments, in which he used 3 lbs. and 4 lbs. of gunpowder; and (4) "that this length is always limited, and in the case of blown-out shots of ½ lb. of powder this limit does not exceed 65 feet for most dusts and only reaches 200 feet in the case of very exceptional dusts." In three of Mr. Hall's experiments, with 1 lb. of powder, the flame attained a vertical height of 60 yards, and with 1½ lbs., 2½ lbs., and 3 lbs. of powder, the flames reached 193 yards. Messrs. Mallard and Le Chatelier's conclusions being based on the ignition of ½ lb. of powder limiting the horizontal distance to 200 feet, the result of Mr. Hall's experiments were not inconsistent with them at all. The difference between the horizontal projection of flame and the vertical projection was very easily shown; for instance, with a burning candle the flame extended upwards, and if a small quantity of coal-dust was thrown into the fire the greater part of the flame went up the chimney; it did not burst out horizontally into the room, but if an explosive was thrown on to the fire the effects were visible horizontally as well as in the vertical direction. In fact, from experiments the mean vertical height reached by the flames appeared to be about three times the horizontal distance traversed by flames.

Mr. W. C. BLACKETT hoped he might be allowed to speak again, for he had omitted to mention one point. When a shot exploded they had a moving mass of air, and if the flame following came in contact with the dust sufficiently mixed with the air, the result was an explosion. His idea was that if they could put something in front of the flame to prevent it following up the moving air they would prevent the explosion travelling through the mine; and he would have liked to see some experiments made to show the effect of putting screens in front of the shots, so that if they blew off they would blow against the screen.

Mr. W. COCHRANE said, as regards Messrs. Mallard and Le Chatelier's conclusion, that coal-dust *per se* was not explosive, that depended on what "explosive" was determined to be. Eighteen or twenty years ago, Professor Freire-Marreco and himself experimented in such a way that fire-damp could not possibly be present. They had a box to imitate a drift, the top being covered with a fine gauze, on which was placed the finest coal-dust they could find, gathered from the deposits about the screens, and dried on a boiler top. They had a small Guibal fan to draw the air along the box. They disturbed the dust so as to cause it to fall, and it was carried with the current of air, into which they now fired a pistol. If the lifting of three small iron weights, and sending them uncomfortably near their heads and quite to the top of the laboratory, could be defined as an explosion, then the dust exploded, for that was the effect of this simple test. In all these experiments which had been referred to, continuity of flame only seemed to have

been established, and it might be difficult to obtain proof of anything further, but he thought he might define the result of the little experiment he had mentioned, and which he had previously recorded, as an explosion.

Mr. J. GERRARD said the subject was one of great importance. He thought they had established the fact that coal-dust *per se* was dangerous, and had left the day far behind when it was necessary to say—"There must have been some fire-damp in or about the place or there would not have been an explosion." It might be an old subject, but they were indebted to Mr. Hall for bringing before them such a graphic illustration of the danger of coal-dust in the entire absence of fire-damp. Several points had been touched upon with regard to the prevention of accidents occurring in connexion with coal-dust. He agreed with Mr. Hall entirely with regard to explosives, but he thought with Mr. Atkinson that the discontinuance of blasting would not remove the danger; that it would still be necessary to look at the danger associated with coal-dust in the face, by reason of explosions and the liability of explosions from other causes than those connected with blasting. As to the danger of coal-dust, he thought it ought to be universally admitted; and as to the advantage of working on roadways free from dust, those who had experience could, he thought, give them some information on that point. The increased amount of work which could be obtained on a roadway free from dust, or when the dust was laid, was to his mind most marked, and, apart from the question of danger, it seemed to him a wonder that it was not dealt with on the ground of increased amount of work and comfort.

The CHAIRMAN said he quite agreed with what Mr. Cochrane had said. Wherever they reduced any substance to a minute form and introduced a flame into it it would explode. If the dust of the floor was not reduced so minutely no explosion would take place, and it was no doubt because of that minute sub-division that the explosion did take place. For instance, if they took a candle into a dusty mine they would find little sparks coming from the wick of the candle, obviously caused by coming in contact with some of the particles of the dust, and supposing the heat was greater there would no doubt be an explosion in such a dusty place. He proposed that a vote of thanks be given to Mr. Hall for his valuable paper.

Mr. N. R. GRIFFITH said he had pleasure in seconding the motion. He was sure they were all indebted to Mr. Hall for the great trouble he had taken in this very important matter.

The proposal was heartily adopted.

Mr. H. HALL said he was very much obliged to the members for the vote of thanks. He was proud to have had the privilege of bringing the paper before the meeting, and though he was afraid it was hopeless for him to attempt now to reply to all the criticisms, he would like to say a few words on one or two points. He wished to make it clear that he was quite a believer in the fact that coal-dust *per se* would explode, but he wanted to be certain also that when exploded or set on fire underground it would behave in the same way as in the experiment

on the surface where there was a ready supply of air to burn it. With reference to the violence: there was considerable violence, and he thought he could best describe it by saying that the noise of the explosion was something like a train rushing through a tunnel. When the explosion arrived at the top, in one case it carried away the handrails over the pulley wheels and lifted the framework of the pit itself. Mr. Steavenson had drawn attention, he believed, to the question of the mechanical condition of the dust, and said that in his opinion it altogether depended upon its fineness. He (Mr. Hall) agreed with him in that, but he differed with him to some extent in thinking there was none of that kind of dust at the face of the workings. He did not know whether they had observed different mines or not, but certainly he found in some of the deep mines in Lancashire that in getting out the pillars there was so much dust that the men frequently watered it of their own accord; they could not work it without. And he was disposed to think an explosion of dust might occur in the face of the workings quite as readily as on the main roads. One gentleman had suggested that it would be better to remove the dust at intervals in preference to watering, but there seemed to be a difficulty, because if they waited for the time to remove the dust there must be a time when the workings would be dangerous from the accumulation of dust; he therefore thought the watering process would be better. He could not deal at present with all the points that had been raised.

Mr. ROBT. F. BOYD (Durham) moved a hearty vote of thanks to the Institution of Civil Engineers for their kindness in allowing the use of their rooms for the General Meeting, and he might also couple with his motion a vote of thanks to all those who had kindly thrown open their works to the inspection of the members. He was sorry that personally he had not been able to avail himself of these opportunities as much as he would have wished.

Mr. T. A. SOUTHERN said he had great pleasure in seconding the vote.

The PRESIDENT put the proposal to the meeting, and it was carried unanimously.

Mr. W. N. ATKINSON proposed a vote of thanks to the Chairman for the able manner in which he had presided over their discussions. It was a great advantage to have a gentleman of the experience and ability of Mr. Embleton to preside over them. He had known Mr. Embleton personally about twenty years, and he was happy to say he was looking as well now as then. They would all hope that he would continue to retain his good health, so as to give them the benefit of his experience in the future.

Mr. W. F. HOWARD (Chesterfield) expressed great pleasure in seconding the motion. He was moving along on the road that Mr. Embleton had been travelling so long, but he could not hope to attain such a green old age.

The PRESIDENT acknowledged the vote, though he said he had really done very little in the matters before them, and had it not been for those who had read and discussed the papers, he was afraid it would have been a somewhat dull meeting. He hoped he would have the pleasure of meeting them all again at Birmingham in September, and that they would again have a good supply of papers.

THE LONDON HYDRAULIC POWER COMPANY.

The London Hydraulic Power Company was established six years ago for the purpose of supplying a cheap and efficient motive power, suitable for the requirements of London. For lifting purposes, hydraulic power is peculiarly adapted. For forty years past, at the docks and railway goods stations, high pressure hydraulic lifting machinery has been generally employed, and also in many large wharves and warehouses, hotels, etc. Through the operations of the company this valuable power has been made available for general public use. This system is equally well adapted for the smallest lift or crane at present worked by hand only two or three times a day, and for the largest installations. The cost of the power, whether for a small or large plant, is in direct proportion to the work done, there being practically no standing expenses.

Nearly 50 miles of hydraulic mains are at present laid in London, between the London Docks and Victoria Station, Westminster, and in Pall Mall, Piccadilly, etc., on the north side, and between Waterloo Bridge and Dockhead on the south side of the river, thus embracing nearly the whole of the City, Westminster, and Southwark. The mains laid in the street are from 7 inches internal diameter to 2 inches. They are chiefly of cast iron with flanged joints and packing rings of gutta percha. The mains are kept charged by powerful pumping engines, located at the Central Pumping Station, Falcon Wharf, Blackfriars; Millbank Street, Westminster; and elsewhere. The reservoirs of power consist of capacious accumulators, loaded to give a pressure of 750 lbs per square inch, producing the same effect as if large supply tanks were placed at 1,700 feet above the street level.

The first Pumping Station erected was that at Falcon Wharf, Holland Street, Blackfriars. At this station there are four Ellington triple compound condensing engines of 200 indicated horse-power each, constructed by the Hydraulic Engineering Company, Limited, of Chester. The boilers are of the Lancashire type, fitted with Vicars mechanical stokers, worked by a Brotherhood hydraulic engine. The water used is pumped direct from the river, and is purified by mechanical filters on the Perrett system, made by the Pulsometer Engineering Company. The filtering medium is sponge.

The pumping station at Millbank Street, Westminster, has been recently erected

and works in connexion with Falcon Wharf. There are three engines here pumping water from the gravel overlying the London Clay, into tanks over the engine. This water contains a large quantity of iron, which is rapidly deposited on exposure to the air. The water is treated by the Porter-Clark lime process, and filtered through presses.

The capacity of the Falcon Wharf Station is 3,000,000, and of the Westminster Station 2,000,000 gallons per week. The present supply to consumers is 5,500,000 gallons per week. A new pumping station near the London Docks has been recently started, which is laid out to deliver 4,000,000 gallons per week.

The cost of the works in London has been so far about £300,000. The present gross revenue of the company in London is about £40,000 per annum. The dividend paid for 1890 was 5¼ per cent.

The hydraulic power is supplied direct to lifts, presses, and fire hydrants, and other apparatus of similar character, without the use of any engine or power-producing machinery; but the hydraulic pressure can also be used for driving engines of special construction in the same way as steam or gas. Hydraulic engines, worked from the company's mains, are now used for all sorts of purposes, such as coffee grinding, ventilating, working elevators and crushers, driving dynamos and general machinery. Their use is so far confined to driving small machinery working intermittently. The hydraulic power may also be used for pumping water from deep wells, or from the basement of a building to a tank on the roof, or for the drainage of cellars, and for supplementing the deficiency of pressure from the waterworks mains. No engine is required, but only small direct-acting rams, which are often allowed to run all night by themselves without any attention, and frequently occupy no floor space at all, being placed below the floor or area.

The progress of the company is best illustrated by the number of hydraulic machines worked from the mains at different periods:—

June, 1884	96
„ 1885	235
„ 1886	389
„ 1887	527
„ 1888	720
„ 1889	910
„ 1890	1,313
„ 1891	1,508

The company has also erected a complete installation for the supply of hydraulic power for working the passenger and service lifts which have been fitted up on the Kensington Court estate. The machinery has been designed to secure a degree of safety, economy and reduction of space occupied, not previously attained. The lifts are intended for domestic use, to be worked by anyone in the houses without an attendant. The only moving part of the lift, apart from the controlling gear, is a plain solid steel ram. The pressure pipes are laid in subways in the streets on the

estate. The working pressure is 400 lbs. per square inch. The pumping station contains duplicate machinery, and is designed to work from 80 to 100 lifts of this class. The only water used is that required for filling the system of pipes, and to make up waste.

THE CITY AND SOUTH LONDON RAILWAY.*

The City and South London Railway Company was incorporated by an Act of Parliament in 1884, and empowered to construct its line from King William Street to the "Elephant and Castle," Newington, and by an Act of 1887 the line was extended to the Clapham Road at Stockwell. An Act of 1890 authorises a further extension to Clapham Common.

The railway at present constructed (Fig. 1, Plate XL.) is rather more than three miles in length. The up and the down lines are carried in separate tunnels placed at such a depth under the surface of the roads as to avoid all interference with sewers and other underground structures. Except where the line is under the river and an adjoining wharf, it passes throughout its whole length under the streets —thus enabling it to accommodate the great stream of passenger traffic between the City and the Borough, Newington, Kennington, Stockwell, etc., now passing over London Bridge, without appreciable deviation from the present course of the traffic.

There are stations at the Monument, King William Street; Great Dover Street (Borough); the "Elephant and Castle"; New Street, Kennington; the Oval; and Stockwell (Fig. 2, Plate XL.).

At each station powerful hydraulic lifts are provided in addition to stairways for the purpose of giving easy and speedy access between the street and the platform levels; and in order to avoid double establishments on opposite sides of the road, at each intermediate station, the up and down tunnels are placed at different levels, so that passengers may pass readily from the lifts or stairs on one side of the road to either platform.

The steepest gradient against the load is about 1 in 30.

The traffic is worked by electricity. The current, generated at Stockwell, is carried by a main insulated conductor through both tunnels. Between the rails is placed, upon glass blocks resting upon the cross sleepers, the working conductor of steel. This conductor is connected with the main conductor at the signal boxes along the line. Upon each locomotive are three collectors or shoes resting or sliding upon the working conductor, and taking up the current as required by the locomotive. A lever on the locomotive enables the driver to regulate the current or to cut it off altogether. Each locomotive, weighing about 10 tons, contains two motors capable of working up to 100 horse-power. By making the axles of the wheels the armatures, all gearing has been dispensed with. The rails form the return conductor and complete the circuit.

Steam locomotives being excluded, the question of ventilation is a very simple one;

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and the traffic in each tunnel being always in one direction, a continuous current of air is established.

The whole of the power required for traction and lifts is concentrated at one point, at Stockwell. Hydraulic pressure and return water pipes are placed throughout the length of the line for the working of all the lifts, and the drainage of the line is secured by the use of small injector hydrants connected with the high pressure main.

The carriages are of the longitudinal type, with platforms and entrances at the ends.

In connexion with the permanent way, no ballast is used, the sleepers resting upon the iron lining of the tunnels.

Some details of the mode of construction of the works may be interesting. The two tunnels for the up and down lines being absolutely separate and distinct between the termini, they were

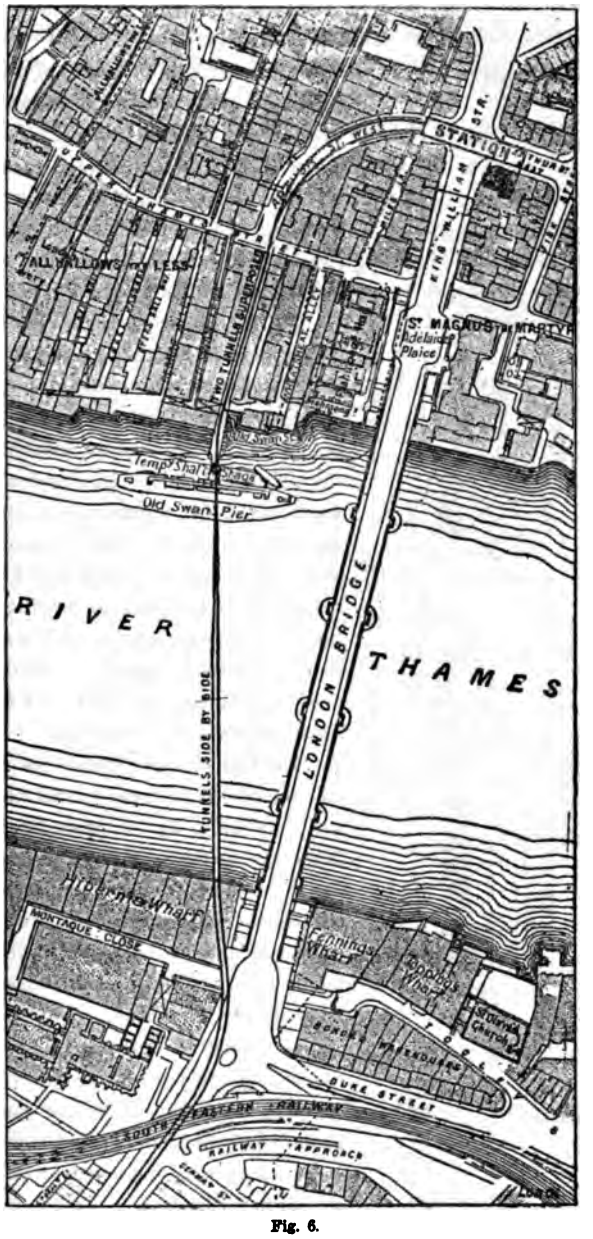


Fig. 6.

capable of being carried in any desired position relatively to each other. Commencing side by side in the City (Fig. 6), the down line falls more rapidly than

the up, in order that when Swan Lane is reached the former may be immediately under the latter, because, except in this position, they could not be constructed without encroaching upon private property or rights. In this position they pass under the northern foreshore of the river Thames, but before the southern shore is reached they are again side by side, and at each intermediate station, as already described, they are at different levels.

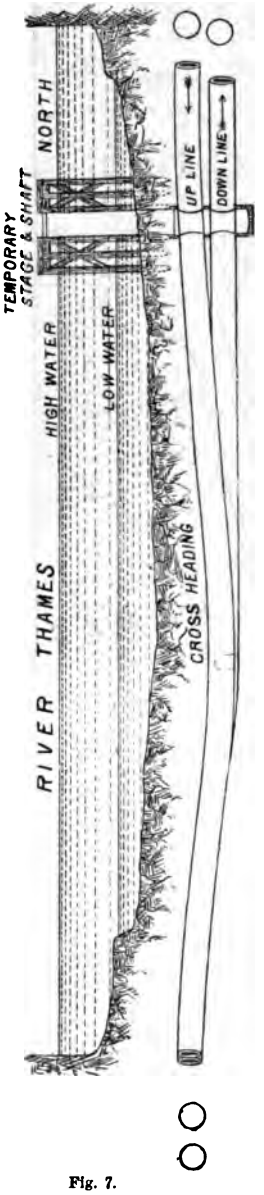


Fig. 7.

Each of the tunnels is 10 feet to 10 feet 6 inches in diameter, and is formed of rings of cast iron segments (Figs. 3 and 4, Plate XL.) bolted together through internal flanges. The rings are 1 foot 8 inches long.

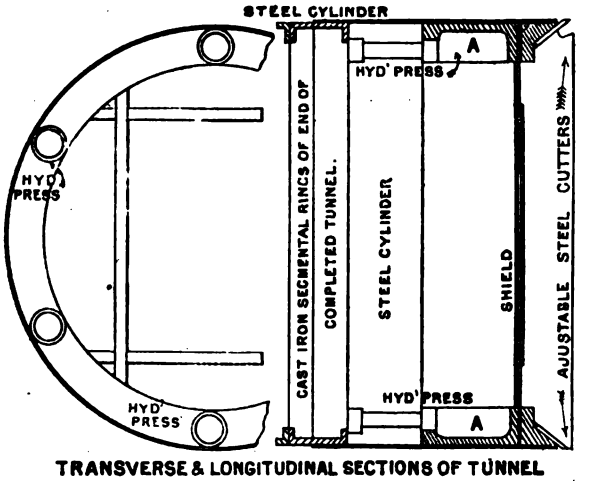
The first operation was to erect a staging in the river at Old Swan Pier for the purpose of sinking a temporary shaft, and constructing the river tunnels (Fig. 7). An iron lined shaft, 13 feet in diameter, was then sunk in the bed of the river, through sand and gravel into the London Clay. From this shaft were driven the two tunnels, northwards to the City terminus, and southwards to near the Borough Station. The second tunnel was driven immediately under, and within 4 feet 6 inches of the upper tunnel, for a considerable length; and after the river tunnels had been driven, work was commenced at the Borough, and subsequently in the City, and at the "Elephant and Castle," and, at a later date, the extension to Stockwell was proceeded with.

The first or upper tunnel has a dip under the river, and the second or lower tunnel rises continuously from the shaft (Fig. 7). A cross heading joining the two tunnels at the lowest point of the first provides for draining that tunnel to the sump at the temporary shaft, whence the small accumulation of water arising from condensation, is discharged by an injector hydrant, deriving its supply of high pressure water from the hydraulic main already referred to.

The mode of constructing the iron tunnels is very simple, and can be described in a few words. A steel cylinder, overlapping (like the cap of a telescope) the forward end of the iron tunnel, is provided, near its front end, with a strong diaphragm or face, having an opening or door in it (Fig. 8).

Beyond this face project adjustable steel cutters and wedges (Fig. 9), and behind it are ranged, round the circumference inside, six

hydraulic presses, so fixed as to abut against the last ring of completed tunnel. As the material is excavated from before the cap or shield by the miners and the action of the cutters and wedges, and thrown back through the opening in the face, the shield is forced forward by the hydraulic presses. The shield thus clears out an exact circle somewhat larger than the outside diameter of the iron lining of the tunnel. The small annular space thus left is filled with grout, composed of Blue Lias lime, by means of an apparatus to be presently described. When the shield has been forced forward sufficiently far a fresh ring of iron lining is built up inside, and under cover of the overlapping steel cylinder. Eight of these rings were regularly erected daily, representing a rate of progress of 13 feet 6 inches at each face, the maximum rate of speed being 16 feet per day.



TRANSVERSE & LONGITUDINAL SECTIONS OF TUNNEL END AND SHIELD.

Fig. 8.

A special apparatus was used for grouting (Fig. 5, Plate XL.). The lime was mixed with water in a cylindrical vessel, the lid closed, and compressed air, at a pressure of about 30 lbs per square inch, from a compressor at the shaft, was admitted through the upper valve, and the lower valve being opened, the contents of the vessel were discharged through a short length of hose pipe, a branch and a nozzle, into the annular space left outside the iron lining by the advance of the shield, holes being provided in each segment of the lining for the purpose. The grout was first of all forced through the lower holes in the segments until it appeared at the holes above; the lower holes were then plugged, and the grout forced into the next holes above, and so on until the grout came out at the topmost hole in which the nozzle was then inserted, and the grout forced in by the full pressure of air until the space

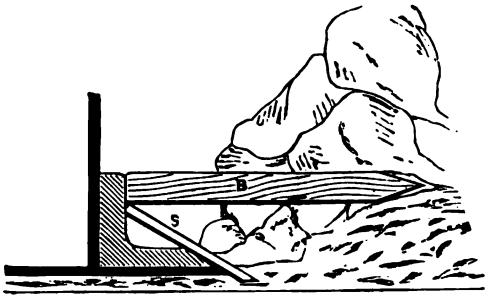


Fig. 9.

was completely filled. By this appliance the iron lining was surrounded by a coating of lime or cement. The paddles upon the spindle were kept continually in motion to mix the grout, and to prevent its setting in the pan.

The tunnels were driven for considerable lengths through sand and gravel under water, at a lower rate of speed, but very successfully, under compressed air. It is interesting to note that since these tunnels were commenced several important tunnels have been constructed or are in progress, on the same plan, in this country and in America.

Mr. J. H. Greathead is the engineer who designed and executed the works, Sir John Fowler and Sir Benjamin Baker being consulting engineers. The main contract for the construction of the subway between the City and Newington was carried out, in part, by Mr. Edmund Gabbutt, of Liverpool, and the extension to Stockwell and the completion of the City section have been carried out by Messrs. Walter Scott & Co., of Newcastle-upon-Tyne.

The electrical plant and locomotives were constructed by Messrs. Mather & Platt, of Manchester, having been designed by Dr. Edward Hopkinson of that firm. Dr. John Hopkinson acted as their consulting engineer, and Mr. J. A. Grindle as their resident engineer throughout. The hydraulic lifts and plant were made by Sir W. G. Armstrong, Mitchell, & Co., Limited.

At the depôt at Stockwell the electricity for working the line is generated by three engines, made by Messrs. John Fowler & Co., Limited, of Leeds, each capable of working up to 375 horse-power and each driving an Edison-Hopkinson dynamo, the current from any two dynamos being capable of working the trains on the line at any time, leaving the third in reserve. The maximum tension of the current is 500 volts.

In the same engine house are three engines and pumps, any two of which will work the hydraulic lifts at all the stations. The water is delivered by the pumps into the accumulator at the engine house, at a pressure of 1,200 lbs. per square inch, and after having passed through the lifts and having done its work it is returned to a tank in the engine house to be taken again by the pumps.

The engines and carriages are conveyed from the railway to the depôt on the surface, by means of an inclined road worked by a small hauling engine.

The boilers are set on the Livet improved principles, by which means and by the use of the Vicars mechanical stokers, the formation of smoke is prevented, and considerable economy of fuel secured.

FIG. 2.

FIG. 4.

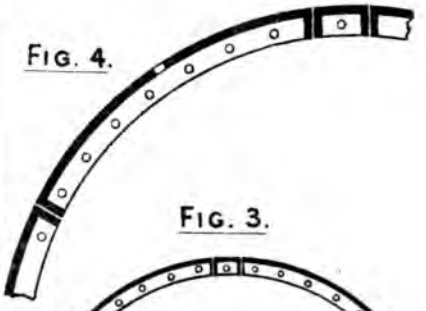
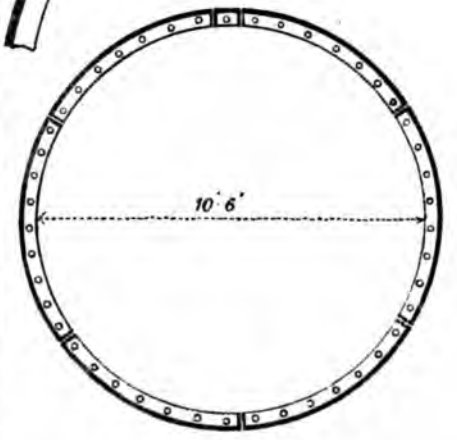


FIG. 3.



THE GENERAL ELECTRIC POWER AND TRACTION COMPANY, LIMITED.

The works of the General Electric Power and Traction Company, Limited (late Immisch & Company), at Kentish Town, were visited. They comprise commodious and well-designed machine and erecting shops, pattern shop, drawing office, and smithy, and are specially adapted for the building of electric machinery. The company turn out both high and low speed machines for lighting, pumping, hauling, winding, etc., and they are also builders of steam dynamos and general mining plant. A number of machines for colliery work were seen in process of building or erection. Amongst other machines was a 100 horse-power dynamo, compound wound, designed for both electric lighting and motor driving, in the way proposed and elaborated by the company's chief engineer, Mr. Albion T. Snell, and described in the Transactions. Electric coal-cutting plant was also seen in course of construction.

The company's electric launch department at Hampton, and the section of the North Metropolitan Tramway Company's line at Barking, which is worked by the General Electric Power and Traction Company by self-contained electric cars, were also inspected.

THE LONDON ELECTRIC SUPPLY CORPORATION, LIMITED.

This company is possessed of Parliamentary powers over a large district, extending from Westminster Bridge to Greenwich on the south side of the river Thames, and Mayfair, Belgravia, St. James, Pall Mall, St. Martin's-in-the-Fields, part of Westminster, and the separated district of Clerkenwell on the north side of the river. The distribution is on the Ferranti alternating current system. The alternating current is generated at a high pressure and transmitted to converting stations, from which it is distributed to the service converters. The company has erected at Deptford a large and commodious central station, which is the largest generating station in the world.

The Grosvenor Gallery station, which is now closed, supplied about 38,000 incandescent lamps, which are now supplied from their Deptford station.

There are twenty-four boilers of the Babcock and Wilcox type, representing a total of 20,000 horse-power, but the boiler houses are constructed to contain boilers equal to the generation of 65,000 horse-power. Economizers are applied for the purpose of utilizing the waste steam by heating the feed-water.

The boiler house is arranged in two floors, and, with two engine houses, cover an area of 39,900 square feet, being 210 feet long by 190 feet wide, and have a height from basement to roof of about 100 feet. The engine houses are separated from the boiler house by a massive wall of masonry, and are each 195 feet in length by 66 feet in breadth, their height being 85 feet. A row of iron pillars separate the two engine houses and at the same time support the roof and the overhead travelling cranes, these latter being required for the lifting of heavy pieces of machinery.

Above the boiler house, forming a third story, provision has been made for the storage of 4,000 tons of coal. The coal, after having been unloaded on to the wharf, is hoisted to this storehouse, and, as occasion requires, distributed to the boiler houses by means of vertical shoots passing to the boiler fires.

The compound vertical engines are four in number, built by Messrs. Hicks, Hargreaves, & Co. of Bolton, two of them indicating 1,500 horse-power each: these drive two Ferranti dynamos by forty cotton ropes on each pulley. The other two engines indicate 750 horse-power each. Ample room has been provided for future extensions. The large Ferranti dynamos are capable of producing 25,000 lights of eight candle-power, and are 12 feet 6 inches high by 15 feet long over all. It is also intended to have three pairs of compound tandem engines, each pair capable of working up to 10,000 indicated horse-power at a speed of 60 revolutions per minute. The dynamo will be placed between the two engines forming the pair, with armatures 45 feet in diameter, the total weight of each machine being about 500 tons.

The dynamos being constructed will work at an E.M.F. of 10,000 volts, and the current, after being conveyed through concentric copper mains to London, is reduced to 2,400 volts at distributing stations. Underground cables run from these distributing stations over the City, and the current is again reduced to an E.M.F. of 100 volts for the purposes of public supply. Up to the present over 48 miles of mains have already been laid.

The Ferranti main is used for the transmission of the current, consisting of an internal copper tube conductor covered with insulating material, which is surrounded by an outer copper tube conductor. Special machinery has been erected for the manufacture of the Ferranti mains at Deptford. They are made in lengths of 20 feet. The inner conductor, consisting of a copper tube of $\frac{1}{4}$ square inch area, is placed upon a trestle and slowly wrapped with brown paper that has been previously dried upon a hot plate, and then passed through a bath of special black oil or wax, which soaks into the paper until the proper thickness of insulation is reached. The outer conductor, consisting of a copper tube of the same sectional area as the inner one, *i.e.*, $\frac{1}{4}$ square inch in area, is then slipped over the tube and insulation, and finally passed through a draw-plate so as to close the outer tube upon the insulation. The main is further insulated with waxed brown paper and taped, and a steel tube placed over the outside for protection. These 20-feet lengths of mains are joined together by suitable tapered tubes and sleeves of copper, so that a solid joint may be effected.

A considerable economy is effected in the cost of the copper conductors owing to the high tension at which the Ferranti system is worked, and there is only a loss of less than 3 per cent. by the use of these mains, which are capable of supplying 100,000 ten candle-power lamps each. The conductors are $2\frac{1}{2}$ inches in outside diameter, with a current density of 1,000 ampères per square inch section of copper.

NOTES ON THE SINKING AT THE LENS COLLIERIES, No. 10 PIT, BY THE POETSCH SYSTEM

By N. R. Griffith.

After the termination of the London meeting of the Federated Institution of Mining Engineers several of the members proceeded to the north of France to visit a shaft being sunk by the Poetsch system through water-bearing strata.

On their arrival at Lille they were met by M. Gobert, of 222, Chaussée de Charleroi, Brussels, the engineer in charge of the freezing arrangements, who accompanied them to Lens, where he introduced them to M. Reumaux, chief engineer of the Lens Collieries, for whom the shaft is being sunk, and then accompanied them to the shaft at Pont-à-Vendin, where every facility was afforded for the inspection of the operations in progress and the fullest information on all points was given by M. Gobert.

The shaft had been commenced on the ordinary method of sinking about two and a half years previously, and sunk in this way about 84 feet, when it was found impracticable to proceed further in this manner, partly on account of the enormous quantity of water met with, which pumping appliances of 1,000 horse-power were insufficient to cope with, and partly on account of a portion of the shaft, which portion had been lined with timber, having been crushed in. (Fig. 1, Plate XLI.)

Of the ground passed through, the upper portion consisted of quicksand and the lower of chalk.

As some of the permanent surface arrangements had been erected, the Lens Company, instead of abandoning the shaft and commencing a fresh one elsewhere, decided to try to put the shaft down through the water-bearing strata by the Poetsch process.

The shaft is 15 feet 9 inches diameter in the clear, and when operations on the Poetsch system commenced was full of water to the natural level of the water in the ground close to the surface. The operations on the Poetsch system, which had been carried out before the visit of the members of the Federated Institution were as follows:—Inside the shaft eight boreholes (Fig. 2, Plate XLI.) were put down to a depth of 137 feet 9 inches from the surface. Outside and surrounding the shaft twenty boreholes were put down to the same depth, at which there is a bed, which it is believed will form a good foundation for the permanent tubbing.

The boreholes were put down in the ordinary way, and lined temporarily with sheet iron casing about $\frac{1}{8}$ inch thick, commencing with 14 inches diameter, decreasing to 10$\frac{1}{4}$ inches diameter, and, finally, to 8 inches diameter.

Inside each borehole, when finished, was placed a flush-jointed wrought iron tube, 4$\frac{1}{4}$ inches diameter, closed at the bottom end, and inside each of these tubes

was placed a 1¼ inch diameter wrought iron tube, with two slotted openings opposite to each other at its bottom end. Much care was taken to secure that the joints of these tubes, and especially of the 4½ inch tubes, were perfectly water-tight (this is most important).

The sheet iron lining of the boreholes was then withdrawn (this also is very important).

The tops of the 1¼ inch diameter tubes were all connected (Figs. 3 and 4, Plate XLI.) with the delivery end of a duplex pump, which forced down them the cooling fluid (hereinafter called the brine), which in French is called "l'eau salée," and is a 20 per cent. solution of chloride of calcium in water, unfreezable, except at an extremely low temperature. The tops of the 4½ inch tubes were connected with the cistern in which the brine is cooled, and from which it is pumped by the duplex pump. The brine is cooled in the cistern, pumped down the 1¼ inch tubes, returns up the 4½ inch tubes to the cistern, is again cooled there, and so on.

The brine is cooled by means of ammonia, which first passes through coils of wrought iron tube in tanks through which tanks a stream of cold water flows. The pressure of the ammonia in these coils is nine atmospheres above the atmospheric pressure, and it is then a liquid. It passes from these coils through a tube to coils of wrought iron tube immersed in the brine in the cistern above-mentioned, in which cistern the brine is cooled. The ammonia expands in these coils in the cooling cistern to a pressure of three-fourths of an atmosphere above the atmospheric pressure, when it is an intensely cold gas which cools down the brine in the cistern—the temperature of the ammonia while passing through the coils in the cistern, is 22 degs. below zero Centigrade—the brine is agitated in the cistern by mechanical agitators to bring it to a uniform temperature.

From the coils in the cistern the ammonia is pumped by a gas-compressing engine, similar in principle to an ordinary air-compressing engine, to the coils in the tanks from which it started.

It will be seen that both the ammonia and the brine are continually circulating, and that there is no loss or waste of either.

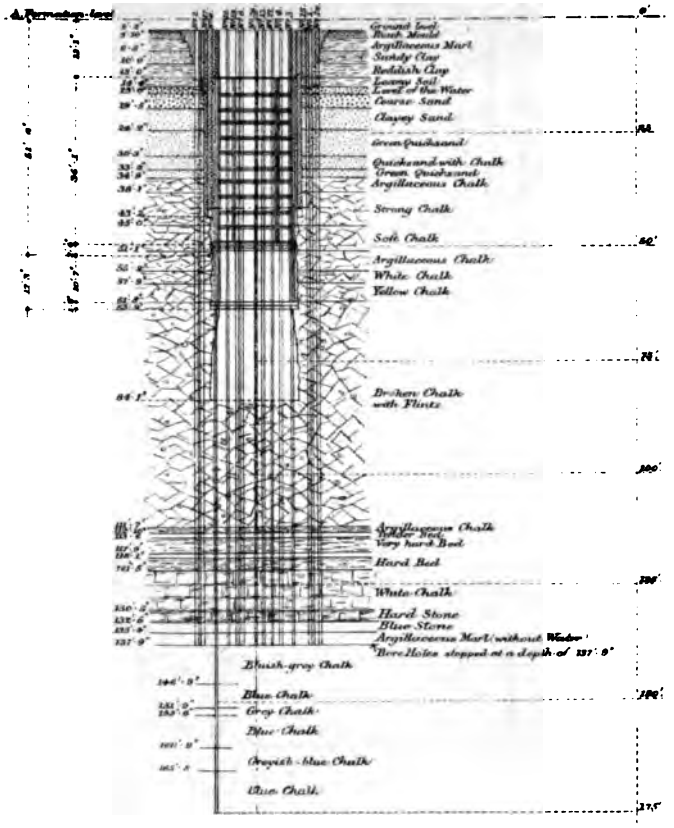
The brine leaves the cooling cistern at a temperature of 12 degs. below zero Centigrade. It returns to it at a temperature of 9 degs. below zero Centigrade.

It should be understood that the production of the cold brine is outside of the Poetsch process, and of the Poetsch patent. The cold brine can be produced by sulphurous acid machines, or by carbonic acid machines instead of ammonia machines.

When the choice of a freezing machine has to be made for freezing a shaft, the preference should be given to a machine capable of producing a brine as cold as 20 degs. below zero Centigrade. This very low temperature will be very useful at the end of the operation, when the cold has to pass through very thick cylinders of ice.

The working cost during the process of freezing is very small, the only items

FIG. 1. Scale 300



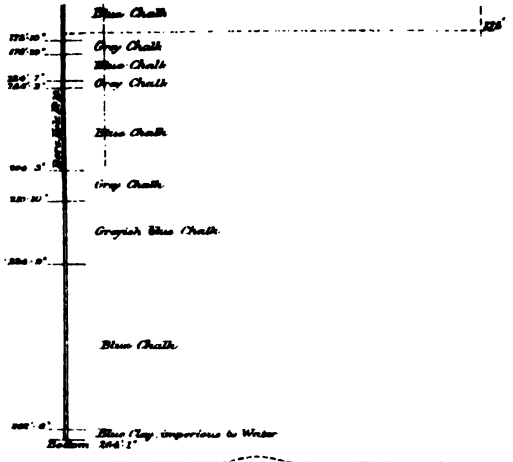
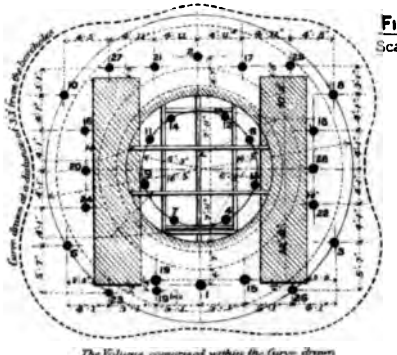


FIG. 2.
Scale 180



The Volume contained within the Curve drawn at a distance of 3'3" from the borehales and a depth of 137'9" is about 342 030 Cubic Feet

FIG. 3.
PLAN.

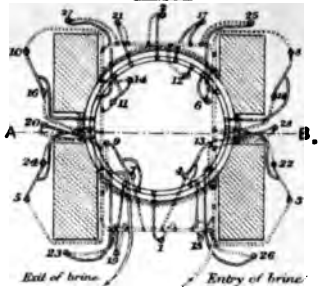
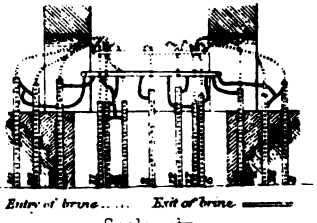


FIG. 4.
SECTION A.B.



Scale 250

And.w Reid Sons & C.o Lithos Newcastle

being fuel for the boilers which supply steam to the gas-compressing engine and brine pump, and the labour of stoking at the boilers and attending to the engines.

On May 29th, 1891, freezing had been going on for 50 days, and the cylinders of ice in the shaft, and frozen ground outside the shaft, surrounding each of the 4½ inch tubes were each 32 inches in diameter at the top, where only they could be examined.

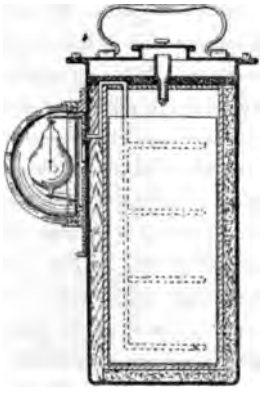
It was supposed that they were larger in diameter at the bottom, because, of course, the brine was colder in the tubes at the bottom than at the top. It was expected that it would take about 70 days more before the cylinders of ice and frozen ground surrounding the tubes would have joined one another and formed a solid cylindrical mass of frozen ground and ice, containing all the 28 tubes.

Then sinking operations would commence, the eight tubes inside the area of the shaft being disconnected from the freezing apparatus and taken out as the sinking progressed, but the freezing operation being continued in the 20 tubes outside the area of the shaft so as to maintain a wall of frozen ground around the shaft until the permanent tubbing had been fixed.

Any leakage in the 4½ inch tubes would be most prejudicial to the success of the freezing operation, as if the brine got mixed with the water in the ground it would render that water very difficult to freeze.

BRISTÖL IMPROVED PORTABLE ELECTRIC SAFETY-LAMP.

The improvements recently introduced by the patentee, Mr. L. Bristöl, of Bromley, Kent, into his portable safety electric lamp, a sectional view of which is illustrated in the annexed woodcut, chiefly consist in making the casing of sheet steel, brass, or suitable metal, flanged around the top for the simple fixing by screws of the cover. This has an opening surrounded by a vertical wall, into which the vent-hole tubes of the secondary battery are projected and fitted with the Bristöl special non-splashing gas plugs, and the whole is protected by a swivelling cover plate, by which ready inspection and re-filling are attained.



Further, to prevent injury to the battery by accidental shocks, a space is left between it and the casing, into which are fitted wooden plates. On the front side the plate is grooved for the reception of the wires from the battery to the glow lamp and the switch. The metal casing itself serves as the negative pole, and the on and off switch is arranged to

cover the positive charging connexion which is insulated from the casing, so that charging can only be effected when the lamp is not burning. The advantage derived from the improvements described are that the lamp is rendered much stronger and less liable to derangement through the rough usage it is liable to, and also the re-charging both with electricity and electrolyte are facilitated while the simplicity of the whole is calculated to considerably reduce the cost of manufacture and increase the life of the lamp.

CUVELIER LOCK FOR SAFETY-LAMPS.*

The Cuvelier safety lock is intended to absolutely prevent miners from opening the lamps entrusted to them. The working of a bolt lock is controlled by the displacement of the ends of a flattened tube, similar to the tube of pressure gauge, which tube is arranged so as to receive liquid under pressure from an accumulator.

PITKIN PORTABLE BATTERIES AND HAND AND MINERS' ELECTRIC LAMPS.

The elements in the Pitkin secondary batteries are an improved form of the pasted lead plate. The active material is spread uniformly over both sides of the elements and being effectually held on by the peculiar form of the cast lead surfaces, the danger arising from the warping of the plates or the disintegration of the active material is reduced to a minimum. The elements are held the requisite distance apart by means of vulcanite pins screwed firmly into the positive plates. The whole of the connexions are protected from the corrosive action of the solution used by means of a thoroughly acid-proof cement.

Each cell is separate and self-contained. When the cells are joined up to form a battery they are placed within a polished oak or walnut wood case. The charging terminals are placed on the side opposite the lantern. A variable resistance is usually placed in the lamp circuit, and is used to regulate the flow of the current. The discharging terminals are either ordinary clamp screws or conical plug holes.

The elements in the Pitkin primary batteries are of the simple zinc-carbon type

* Transactions of the North of England Institute of Mining and Mechanical Engineers, Vol. xxxvi., pages 51-54, Plates VII. and VIII.

and will therefore work with any of the single fluid excitants now so well known. A variable resistance is placed in the lamp circuit, so that if an alteration in the nature of the charging solution be made, the pressure at the lamp terminals can be varied to suit the voltage of the lamp. The lamp is lighted or extinguished by raising or lowering the central spindle by means of the handle.

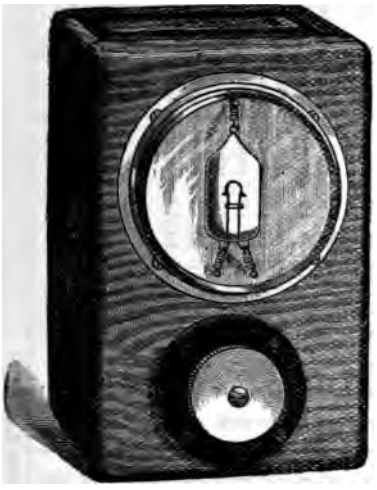


Fig. 1.

Fig. 2.

Fig. 3.

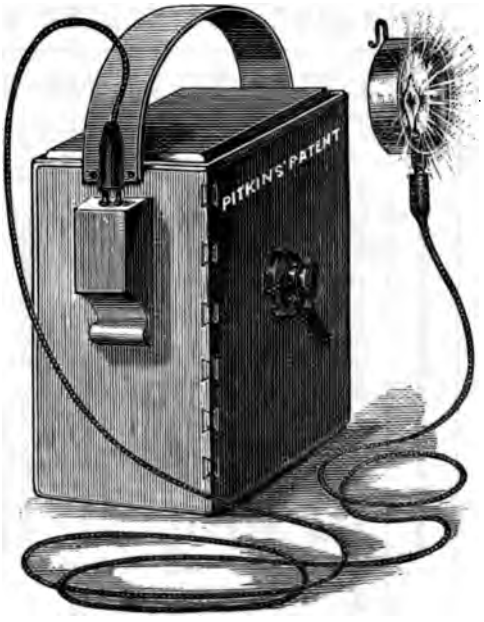


Fig. 4.

EXHIBITS OF ELECTRIC MINING AND OTHER PORTABLE LAMPS.

Name of Exhibitor and Description of Lamp.	Dimensions. Height.	Width.	Depth.	Weight when Charged.	Candle-power.	Duration of Light.	Case.	Lid.	Lantern.	Glass of Lantern.
	Ins.	Ins.	Ins.	lbs. oz.		Hours.				
Mr. L. BRISTÖL, Park End, Bromley, Kent :—										
1. Small, 3-cell secondary battery	4·5	2·4	2·4	2 3	1	4 to 5	wood	metal	fixed	bull's-eye.
2. Medium, 3-cell secondary battery	6·2	2·8	3·0	4 2	1½	8 to 10	wood	metal	fixed	bull's-eye.
3. Do. do.	5·9	2·7	2·8	5 2	1½	8 to 10	metal	metal	fixed	bull's-eye.
4. Large, 4-cell secondary battery	7·0	2·9	3·3	5 5	1½	12 to 15	wood	metal	{detachable, with cable}	bull's-eye.
Messrs. CATHCART, PETO, & RADFORD, 57B, Hatton Gardens, London, E.C. :—										
1. S.C.P. miner's electric safety-lamp*	8·0	4·0	...	5 0	1	8	copper	brass	fixed	cylindrical.
2. Secondary battery belt and hand lamp ...	4·2	1·3	...	4 2	1½	6	leather	leather	attachable	plane.
Mr. JAS. PITKIN, Red Lion St., Clerkenwell, London :										
1. Primary battery hand lamp ... (Fig. 3)	9·2	4·5	4·5	5 11	...	6 to 8	wood	wood	fixed	plane.
2. Do. do. ... (Fig. 3)	9·2	4·5	4·5	6 0	...	6 to 8	wood	wood	fixed	bull's-eye.
3. Portable 2-cell secondary battery lamp ...	6·8	3·7	2·7	5 11	1	5 to 6	copper	copper	fixed	bull's-eye.
4. Pocket 2-cell secondary battery lamp (Fig. 1)	5·4	3·5	1·4	1 13	1	5 to 6	wood	wood	fixed	plane.
5. Do. do. ... (Fig. 1)	5·6	4·0	1·6	2 8	1	5 to 6	wood	wood	fixed	plane.
6. Do. do. ... (Fig. 1)	5·6	4·0	1·6	2 8	1	5 to 6	wood	wood	fixed	plane.
7. Detachable sling 4-cell secondary battery and hand lamp	5·2	4·1	2·5	4 4	1	5 to 6	leather	leather	attachable	plane.
8. 4-cell secondary battery miner's lamp (Fig. 2)	7·0	4·1	4·1	8 7	4	10 to 12	wood	wood	fixed	plane.
9. Do. do. (Fig. 2)	7·0	4·1	4·1	8 7	4	10 to 12	wood	wood	fixed	plane.
10. Do. do. (Fig. 2)	7·0	4·1	4·1	8 7	4	10 to 12	wood	wood	fixed	plane.
11. Do. do. (Fig. 2)	7·0	4·1	4·1	8 13	4	10 to 12	wood	wood	fixed	bull's-eye.
12. Do. do. (Fig. 2)	6·8	4·9	3·4	6 9	4	10 to 12	wood	wood	fixed	plane.
13. Do. do. (Fig. 4)	6·8	4·1	4·4	8 7	4	10 to 12	wood	wood	{detachable, with cable}	plane.
14. Do. do. (Fig. 4)	6·8	4·1	4·4	8 10	4	10 to 12	wood	wood	{detachable, with cable}	bull's-eye.
Messrs. WOODHOUSE & RAWSON, United, Limited, 88, Queen Victoria Street, London, E.C. :—										
1. Bristöl medium 3-cell secondary battery lamp	6·2	2·8	3·0	4 3	1½	8 to 10	wood	metal	fixed	bull's-eye.
2 Pitkin 4-cell secondary battery miner's lamp	7·0	4·1	4·1	9 0	2½	16	wood	wood	fixed	bull's-eye.
3. Do. do. do.	7·0	4·1	4·6	8 10	2½	16	wood	wood	{detachable, with cable}	bull's-eye.

* See Transactions, Vol. ii, page 88.

MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS.

MEETING,

HELD AT THE INSTITUTE ROOM, BARNSLEY, MAY 13TH, 1891.

MR. W. E. GARFORTH, VICE-PRESIDENT, IN THE CHAIR.

The minutes of the last meeting were read and confirmed.

The following gentlemen were elected Members of the Institute, having been previously nominated:—

Professor W. E. Benton, Mining Engineer, Pitt Street, Sydney, N.S. Wales.

Mr. Herbert Harper, Civil and Mining Engineer, Pitt Street, Sydney, N.S. Wales.

The CHAIRMAN suggested that as the attendance was very small, owing to the prevailing epidemic of influenza, it would be well to adjourn the meeting, and this was agreed to.

MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS.

ANNUAL MEETING,

HELD AT THE INSTITUTE ROOM, BARNSLEY, AUGUST 5TH, 1891.

MR. JOS. MITCHELL, PRESIDENT, IN THE CHAIR.

The minutes of the last meeting were read and confirmed.

The following gentlemen were elected Members of the Institute, having been previously nominated :—

Mr. T. B. A. Clarke, Electrical Engineer, 71, Queen's Crescent, Haverstock Hill, London, S.W.

Major Waterhouse, Mining Engineer, Glass Houghton Colliery, Castleford.

Mr. T. B. Lowrance, Mechanical Engineer, Barnsley.

Mr. Geo. Foster, Mechanical Engineer, 40, Dixon Street, Rotherham.

Mr. Jas. Elce, Surveyor and Assistant Colliery Manager, Hoyland Silkstone Colliery, Barnsley.

Mr. W. Washington and Mr. A. M. Depledge were appointed scrutineers of the voting papers for the election of officers for the year 1891-92.

The Annual Report of the Council was read as follows :—

THE COUNCIL'S ANNUAL REPORT.

The Council in presenting their Annual Report for the year ending June, 1891, to the members of the Institute have to state that the following papers have been read :—

"Presidential Address." By Mr. Joseph Mitchell.

"On the Coal-fields adjoining Barnsley." By Mr. Robert Miller.

"On the Parker and Weston Pump for Colliery Purposes." By Mr. George Blake Walker.

The number of members on the books of the Institute at the end of the year was 3 Life Members, 18 Honorary Members, and 168 Ordinary Members. This is an increase of 15 in the number of Ordinary Members.

The Council regret to report that the number of subscriptions in arrear has increased to the extent of £22 7s. over the year 1889-90.

The papers read during the past year are fewer in number than during the previous year, and the Council would impress upon individual members the desirability of furthering the interests of the Institute by contributing papers upon such phenomena as may occur daily in the mine.

The Council also regret the indifferent attendance of the members at the local meetings, and would impress upon them the desirability of members showing their interest in the success of the Institute by attending at every available opportunity; better discussions would take place, as not only are papers read before this Institute open for discussion, but those read before the other Federated Institutes.

The Council congratulate the members upon the fact that one of their Past-Presidents (Mr. T. W. Embleton) was elected President of the Federated Institution during the past year.

On April 11th a very successful meeting of the Chesterfield and Midland Counties Institution and this Institute was held at Sheffield, when a most interesting discussion took place upon Mr. Maurice Deacon's paper "On Comparative Experiments with a Capell and a Schiele Fan working under similar conditions," and Mr. George Blake Walker's paper "On Coal-getting by Machinery."

The Council of the Federated Institution have appointed Mr. M. Walton Brown as Secretary of that Institution and made arrangements with him for the better issue of the Transactions, which now come out in a more regular order than hitherto.

The Council hope that, as the Federation scheme is now in good working order, the members will assist them in maintaining the efficiency of the Institution. It was not with a view of obliterating the local Institutes that the Federated Institution was formed, but with the object of enabling the experience gained by members of local Institutes to be more widely spread, and of promoting greater intercourse between the various coal-mining districts represented by local Institutes; to maintain this efficiency it is essentially necessary that the Council should be well supported by the attendance of the members at the meetings, the reading of papers at such meetings and discussions thereon.

Referring to the accounts, which appear satisfactory to the Auditors, it will be noticed that during the past year the payment of the account owing to the late printers has been completed, and that the only liability for printing is that due to the Federated Institution.

In conclusion, the Council hope that members will arrange for payment of their subscriptions, which are now due, as this Institute has to forward the calls made by the Federated Institution, which, if not received in due course by that newly formed Institution it cannot continue.

The PRESIDENT moved the adoption of the Council's report. He would be glad to hear the remarks of any gentleman upon it. The arrears since the writing of the report had been reduced by £15.

Mr. J. NEVIN seconded the motion.

The report was adopted.

ACCOUNTS.

The Statement of Accounts for the past year was read as follows:—

THE TREASURER (T. W. H. MITCHELL) IN ACCOUNT WITH THE MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS, 1890–91.

DR.

1890.	£	s.	d.
July 1.—To Balance at Bankers	101	16	10
,, ,, Cash in Treasurer's hands	3	2	5
1891.			
June 30.—To Members' Subscriptions	237	12	0
,, ,, Sale of Dinner Tickets	10	3	6
,, ,, ,, ,, in connexion with the Joint Meeting with the Chesterfield Institute	15	15	0
,, ,, Members' portion of the Wine Account at the Annual Dinner	10	6	6
,, ,, Members' portion of the Wine Account at Dinner—Joint Meeting with the Chesterfield Institute	5	8	6
,, ,, Sale of Transactions	4	5	2
,, ,, Chesterfield Institute—Half Expenses in connexion with Joint Meeting	3	10	2
,, ,, Bank Interest	1	19	6
	£393	19	7

Audited and found correct, { GEO. JNO. KELL. / ALFRED B. SOUTHALL.

CR.

1891.	£	s.	d.
June 30.—By R. E. Griffiths	34	7	9
,, ,, Reporter	10	15	0
,, ,, Royal Victoria Hotel, Sheffield, Dinner—Joint Meeting with Chesterfield Institute	24	11	6
,, ,, King's Head Hotel, Barnsley, Annual Dinner	28	10	6
,, ,, Secretary's Salary, one year	25	0	0
,, ,, ,, Expenses	15	8	1
,, ,, Barnsley Gas Co.	0	4	4
,, ,, Hire of Rooms for Meetings in Leeds and Sheffield	1	7	6
,, ,, Rent of Room	12	0	0
,, ,, Insurance	0	15	9
,, ,, Lowrance & Son	0	7	6
,, ,, Federated Institution of Engineers:—			
Balance of Call for year 1889-90 ... ... £92 1 3			
Call of 7s. 6d. on 168 Members for 1890-91... ... 63 0 0			
Call of 5s. on 9 Hon. Members for 1890-91 ... 2 5 0			
Payment on account of Second Call for 1890-91 4 10 0			
	161	16	3
,, ,, Room Cleaning	0	13	0
,, ,, Stamps, Telegrams, Post Cards, & Sundries	12	12	1
,, ,, Balance at Bankers...	64	12	11
,, ,, Cash in Treasurer's hands	0	17	5
	£393	19	7

MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS.

GENERAL STATEMENT, 1890-91.

1891.	LIABILITIES.	£	s.	d.
June 30.—To the Federated Institution of Engineers :—				
	Balance of Call for 1890-91	60	15	0
„ „	Reporter	6	10	0
„ „	Barnsley Gas Co.	0	1	0
„ „	Balance, being Capital	409	15	4
		£477	1	4

1891.	ASSETS.	£	s.	d.
June 30.—By Cash in Bank		64	12	11
„ „ „	Treasurer's hands...	0	17	5
„ „	Estimated Value of Instruments for Fan Experiments (one-third portion) ...	16	0	0
„ „	Arrears of Subscriptions	58	1	0
„ „	Value of Transactions, 6,750 at 1s. per copy	337	10	0
		£477	1	4

Audited and found correct, { GEO. JNO. KELL. / ALFRED B. SOUTHALL.

The PRESIDENT said there was no valuation of their library. There were many books which they ought to get bound by some means or other. He thought an application to the various colliery owners for subscriptions would be advisable. He then moved the adoption of the accounts.

Mr. J. LONGBOTHAM seconded the motion.

The motion was carried.

Mr. J. LONGBOTHAM—Following up the President's suggestion about the binding of those books, if there were no other means of obtaining money he suggested that the Secretary be instructed to draft a circular letter to the coal owners on the subject, after ascertaining the cost of binding.

Mr. NASH—Certainly an effort should be made to have them bound.

Mr. J. LONGBOTHAM moved a resolution to that effect.

Mr. NASH seconded the motion, which was carried.

REPRESENTATIVES ON THE COUNCIL OF THE FEDERATED INSTITUTION OF MINING ENGINEERS.

The PRESIDENT—The result of the ballot for representatives on the Council of the Federated Institution, for the year 1891-92, was as follows (Mr. Nash and the President were scrutineers) :—

The President (Joseph Mitchell, Esq.).	T. W. Embleton, Esq.
C. E. Rhodes, Esq.	T. Carrington, Esq.

A. M. Chambers, Esq.

The minutes of the last meeting of the Council of the Federated Institution, held on May 28th, were read.

ELECTION OF OFFICERS.

The Scrutineers reported the result of the election of officers for the year 1891-92 as follows :—

PRESIDENT.—Jos. Mitchell, Esq., M. Inst. C.E., F.G.S.

VICE-PRESIDENTS.—W. E. Garforth, Esq., J. Gerrard, Esq., J. Nevin, Esq.

COUNCIL.

G. B. Walker, Esq.	H. B. Nash, Esq.
W. Henry Chambers, Esq.	S. H. Hedley, Esq.
J. Longbotham, Esq.	J. Jarratt, Esq.
G. J. Kell, Esq.	Wm. Hargreaves, Esq.

SECRETARY AND TREASURER.—T. W. H. Mitchell, Esq.

Mr. J. LONGBOTHAM moved that the thanks of the Institute be given to the President for his services during the past year. He was sorry that a larger number of papers had not been read. He believed to a certain extent that the Federated Institution was to blame for fewer papers being read here, and he would strongly urge upon anyone who had a paper to read, that he should offer it to this Institute before offering it to the Federated Institution. Mr. Walker for instance, read a long paper upon the Australian Coal-fields before the Federated Institution which was of great interest, but perhaps it would have been better if he had given it first as an instalment to the Midland Institute. This Institute appeared only to have contributed three papers to the combined Transactions of the Federated Institute during the year.

The PRESIDENT—Last year we were first, we had one more than the others.

Mr. J. LONGBOTHAM—The Institute was greatly indebted to the President for the manner in which the business of the Institute had been conducted during the past year, and he hoped that the President during the coming twelve months would show as great energy as he had in the past.

Mr. EMBLETON seconded the resolution and said with respect to papers being read at the Federated Institution instead of at a local institute, that more honour appeared to accrue to the author of a paper if he read it to the larger assembly, rather than at the separate institutes.

The motion was carried unanimously.

The PRESIDENT said it had been a great pleasure to have the honour of presiding over the Midland Institute. He regretted, with the Council, that there had not been more work done. He thought if they had more joint meetings, as that with the Chesterfield Institution, it would perhaps cause writers of papers to feel that there was a little more prestige attached to their work. He should like to see the papers of the Federated Institution more adequately discussed by their local Institutes. Up to now, he believed their Secretary had never been called upon to put any particular paper upon the agenda. If some member would be good enough to give him notice to enter upon the agenda some paper read at any of the other Institutes, or at the Federated Institution, they would get some good discussions. It was evident that unless there was something very interesting members would not turn up in such large numbers as when something interesting and new was under discussion. In concluding, he thanked the members for their complimentary vote.

Mr. EMBLETON suggested that a selection of papers to be discussed might be made and given to the Secretary, which would perhaps be the easiest way of getting over that difficulty.

Mr. J. LONGBOTHAM agreed with the suggestion.

The PRESIDENT said they should not part to-day without according thanks to the officers,' Vice-Presidents, and Council, who had done their work in the past year. He was sure that a few of them had stuck to their work very well, though there had been a lack of attendance even at Council meetings. He did not think

that it had been intentional, but because there had been other work preventing them being present. He had great pleasure in moving that their best thanks be given to the Vice-Presidents and Council of the past year.

Mr. THIRKELL had great pleasure in seconding the vote of thanks. He had done little indeed himself for the Institute, and attended few meetings. He hoped during the coming year that there would be more papers than they had had in the past, and that the Institute would take the place it held before as the premier institute, as far as papers were concerned.

The motion was carried and the meeting ended.

The Annual Dinner was afterwards held at the King's Head Hotel Barnsley.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,

JUNE 13TH, 1891.

MR. WM. COCHRANE, PRESIDENT, IN THE CHAIR.

SECRETARY AND TREASURER.

The PRESIDENT said that the council had that day given the appointment of Secretary to the Institute to Mr. M. Walton Brown, who had for many years been closely connected with them as a member of Council and as a contributor of papers, he would, no doubt, continue to devote every attention to the interests of the Institute. The appointment of Treasurer had been given to Mr. Reginald Guthrie.

The SECRETARY (Mr. M. Walton Brown) read the minutes of the last meeting, and reported the proceedings of the Council.

The SECRETARY then read the balloting list for the election of officers for the year 1891-92.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. D. Selby Bigge, Electrical Engineer, 27, Grey Street, Newcastle-on-Tyne.

Mr. Joseph J. Henderson, Civil Engineer, U.S. Engineer's Office, Kingsbridge, New York, U.S.A.

ASSOCIATE MEMBER—

Mr. John Hunt Hedley, Valuer, John Street, Sunderland.

ASSOCIATES—

Mr. Edward Griffith, Assistant Manager and Surveyor, Fitzwilliam Hemsworth Colliery, Wakefield.

Mr. William Parkinson, Back Overman, South Moor, Chester-le-Street.

The following gentlemen were nominated for election:—

MEMBERS—

Mr. Ernest F. Ayton, Mining Engineer, El Botè Mining Negociacion, Zacatecas, Republic of Mexico.

Mr. Charles Spearman Carnes, Colliery Manager, Peases' West Colliery, Crook.

Mr. Robert Middleton, Hydraulic Engineer, Sheep Scar Foundry, Leeds.

Mr. John Stukley Palmer Samborne, Mining Engineer, Timsbury House, Bath.

Mr. Samuel Hare, Mining Engineer, Brymbo Collieries, Wrexham, North Wales.

Mr. Wm. Hay, Jun., Manager of Mines, Wood View House, Stanton, Burton-on-Trent.

Mr. George Hurst, Mining Engineer, 58, Eldon Street, Newcastle-on-Tyne.

ASSOCIATE MEMBER—

Mr. Edward Ellison Bigge, Secretary, General Mining Association, Blomfield House, London Wall, London, E.C.

STUDENTS—

Mr. David Douglas, Mining Student, Trimdon Grange, R.S.O., Co. Durham.

Mr. Nelson Ashbridge Simpson, Student Mining Engineer, North Navigation Collieries, Maisteg, Bridgend, South Wales.

Mr. J. KENNETH GUTHRIE then read the following paper on the "Pumping Appliances at Eltringham Colliery":—

PUMPING APPLIANCES AT ELTRINGHAM COLLIERY.

By J. Kenneth Guthrie.

This colliery, a little to the west of Prudhoe-on-Tyne, and on the western verge of the Northern Coal-field, is worked by two pits.

1.—The old, or Eltringham Colliery, producing coal and clay from the Brockwell Seam; and

2.—The new, or West Tyne Colliery, sunk to and working the Crow Coal Seam, 14 fathoms below the Brockwell Seam, and 45 fathoms from the surface, the seam at this point consisting entirely of cannel, averaging about 1 foot 7 inches in section. It is to the latter colliery, where a large feeder of water was met with, that this paper will apply.

It may be of interest to give a section below the Brockwell Seam, as little is generally known of this ground:—

	Fms.	Ft.	In.	Fms.	Ft.	In.
Shaft.—Brockwell Seam	0	2	6			
Seggar	0	2	9			
Grey metal, with post girdles	1	2	4			
Black metal	0	0	2			
COAL	0	1	6			
Strong grey post	0	5	3			
Dark grey metal	0	4	1			
Light grey metal, with post girdles ...	1	0	9			
COAL	0	0	6			
Seggar	0	5	0			
Dark grey metal	1	4	2			
COAL	0	1	3			
Seggar	0	1	6			
White and grey post	4	1	0			
Dark grey shale	1	2	0			
Black shale	0	2	1			
COAL—*Crow Coal*	0	1	6			
				13	5	10
Seggar	0	1	8			
White and grey post, with water ...	1	0	0			
Carried forward	1	1	8	13	5	10

	Fms.	Ft.	In.	Fms.	Ft.	In.
Brought forward	1	1	8	13	5	10
Borehole.—Hard white post, with thin partings and water	3	0	5			
COAL	0	0	8			
Soft grey metal	0	1	7			
Hard white post, with metal and water	2	4	7			
Hard white post, with whin balls ...	2	4	0			
Hard white post, with 6-inch gullet at top, and water	1	0	1			
Soft grey metal, with thin post girdles...	1	4	9			
COAL, soft	0	0	4			
Black stone	0	0	3			
Light grey metal	0	2	7			
Into hard white post, with water ...	0	2	4			
				13	5	3
Total below Brockwell Seam				27	5	1

The shaft was sunk dry to the Brockwell Seam, where a feeder of 400 gallons per minute was met with, and a 14-inch sett was put in, worked by a double Ruston and Procter compound engine, 20-horse-power, cylinders 9 inches and 14 inches, with boiler on top; geared 7 to 1, and T-bob quadrants.

This kept the sinking going till within 6 fathoms of the Crow Coal Seam, when the feeder increased to 700 gallons per minute, then a second 14-inch sett was put in, worked by the same engine, and with these two setts the Cannel Seam was won. But the work proved too heavy for this engine, and another of locomotive type, with two 16-inch cylinders and 5-feet stroke, was erected, and worked the two 14-inch setts until 6 feet of sump was put on. The water continued increasing till pumps were going 24 strokes and engine 96 strokes per minute, and lifting 1,550 gallons, but owing to the high speed breakages were very frequent.

Iron water-cages were now put in, during the day the pit drawing coal and stone on one side and water on the other, at night both water-cages were in. They held 418 gallons, and were constructed of best Low Moor iron, and made by Messrs. Joseph Cook & Son, Washington. They ran in wood guides in the same way as an ordinary cage, and were provided with self-acting teaming gear.

It was soon found necessary to put in another sett, and one 19-inches diameter was put in provided with a 15-feet working barrel, so that it could be worked with any type of engine which it might afterwards be decided to erect. At this time it was worked by the 20-horse-power engine, formerly mentioned, geared 14 to 1, working a 4-feet stroke, the other engine being brought down to 16 strokes, the water-cages being done away with for a time.

Owing to increased feeder of water these arrangements were soon found inadequate, and as the speed of the pumps and engines were so great and the boilers not what they should be, it was decided to erect a powerful pumping engine, sufficiently large to keep under any probable feeder that might hereafter be met with. Various plans were considered which need not be entered into, as this paper is not meant to advocate any special type of engine, but simply to illustrate an arrangement which has successfully met and conquered difficulties, and which has given every satisfaction.

The engines were supplied by Messrs. Carrick & Wardale, and consist of a double horisontal compound condensing engine of the tandem type (see Figs. 1 and 2, Plate XLII.), having two cylinders, and one air-pump in a direct line on each bed-plate, the two high pressure cylinders being 19 inches diameter, and the two low pressure cylinders, 35 inches diameter; the two air-pumps are 10 inches diameter with a stroke of 5 feet common to all; the engine crank-shaft is fitted with two cast steel spur-pinions and balanced with a heavy fly-wheel, these spur-pinions are geared into a counter-shaft, on which are fitted two massive cast spur-wheels 13 feet diameter, and $3\frac{1}{16}$ pitch, shrouded on both sides, the gearing being 4 to 1; on each end of this counter-shaft are fitted two very heavy double-ended forged steel cranks having three variable throws so as to alter the stroke of pumps in pit as may be required; these cranks in their turn are coupled direct to pumping quadrants by means of heavy forged steel connecting rods.

The engines were fitted with variable expansion gear fitted to each of the high pressure cylinders and actuated from the outside, so that the cut-off may be regulated to suit the requirements of the load. Provision was also made for admitting high pressure steam into the low pressure cylinders for starting, and the engines are controlled by a powerful governor, hereafter described.

In case of breakdown or repairs, each engine can be worked independently of the other, and the air-pumps can be shut off and the engines allowed to exhaust into the atmosphere, either with one engine or two, and from this it will be recognized that every precaution has been taken to avoid stoppages or laying the pit idle if repairs are needed to pumping set quadrants or one of the engines.

The whole of the gear, including crank-shaft, counter-shaft, piston rods, connecting rods, and valve spindles, are of forged Siemens-Martin steel, and the cylinders are lagged with silicate cotton to prevent condensation. The whole engine throughout is very massively built, and all wearing surfaces are very large; care having been taken to make as many parts as possible adjustable. They are bolted down to a solid concrete foundation about 16 feet deep. Some idea of the size of the engines may be gleaned from the length of the bed-plates, which are 60 feet long. The repairs have been almost *nil* since starting in 1886, and as yet the engines show no signs of needing any.

Quadrants.—There are two steel quadrants fitted on rocking shafts, having two large plummer blocks, supported on each side by two heavy bed-plates. The south

side quadrant is 37 feet 2 inches long and 11 feet 11 inches high, fitted with two steel gudgeons over pumps; that on the north is 34 feet 10 inches long and 11 feet 11 inches high, with one steel gudgeon. The plates and angles are of Staffordshire quality, capable of bearing a tensile strain of 20 tons per square inch; bolts and rivets are of best scrap iron, and the shafting and gudgeons of best hammered Siemens-Martin mild steel. The plummer block for the shafts are of cast iron, and have a bearing 12½ inches by 17 inches long. There are four bed-plates 13 feet long, of cast iron, and of box pattern, 1 foot 4 inches deep by 1 foot 8 inches thick, stiffened by webs; they are secured to concrete foundations by means of four 3-inch holding-down bolts, forged from best scrap iron. The stroke of the quadrants at the spear end can be varied from 6 to 10 feet. They are balanced by cast iron weights, about 2 tons 5 cwts. each, it being arranged to easily remove or add a weight.

Connecting rods to pump crank are 25 feet in length, and are of the same steel as that of shafting and gudgeons.

The spear rod ends are 17 feet in total length, of forged scrap iron, with gun-metal brasses, and wrought iron keys. The sneck key is made bigger in the centre, so that in case of a break it will not fall out. Instead of the rod end being made in one piece, it is made in two halves, so that if a breakage occurs one side can be renewed without taking the whole piece off. The top spear is plated on the four sides.

The spears are of best pitch pine, 29 feet long and 9 inches square, connected by spear plates, 15 feet long, 7 inches broad, 1½ inches thick in the centre and tapered to ⅞ths of an inch. The bolts are 1¼ inches square, specially made of best scrap iron, placed 14 inches from centre to centre. Clink bolts, ⅞ inch, round iron, are put in the opposite way, and the same distance apart. Upon each lift are two kep-wings of wood, bolted to spears, which in case of a fall are caught by buntons.

Pumps.—The shaft is 12 feet diameter. There are in it at present four bucket lifts, two 14-inch setts (see Fig. 2, Plate XLII.), worked by the engine before-mentioned; one 24-inch sett worked off north quadrant of new engine, and one 19-inch sett worked by south quadrant. Room is left to put in a second 24-inch sett, to be worked off spare gudgeon of south quadrant. The 14-inch setts, with 4 foot stroke, are only worked when the big engine is standing.

The 24-inch setts with 8 feet stroke and the 19-inch with 10 feet stroke raise together 277 gallons per stroke. They usually run 7 strokes, giving a feeder of 1,939 gallons per minute. They can run up to 12 per minute, or over 3,300 gallons, and with the 14-inch setts going at the same time, 20 strokes per minute, giving 1,000 gallons, gives a total delivery of 4,300 gallons. If an additional 24-inch sett be found necessary, 1,800 gallons extra could be raised, bringing capability up to 6,100 gallons per minute.

In the midst of these four pumps all coal and stone is drawn.

The height of lift to the Six-Quarter Seam where water is delivered is 28 fathoms. The water-level being through old workings, very much broken up, is laid with iron

pipes 2 feet diameter, wedged with wood, and if there should be a stoppage the water can be turned into another level in the Yard Seam.

When the feeders were first met with, a rain-gauge was established to see if the rainfall had any influence on the amount of the feeder; but there appears to be practically no relation between the rainfall and the feeder, and no doubt some deep-seated feeder coming from a considerable distance is being pumped. Most of it comes from the post in the bottom of sump. On January 20th, 1889, the temperature of the river water was taken and found to be 66 degs. Fahr., immediately afterwards it was taken down the pit where there was then a considerable feeder, and with the same thermometer was found to be 44 degs. Fahr., a difference of 22 degs.

The pump trees are in 10-feet lengths, of cast iron, $\frac{1}{8}$ inch in thickness, with ordinary spigot and faucet joints, an iron ring wrapped with flannel soaked in Stockholm tar being used to make the joint. All air joints, or those below the bucket, are made with lead weezes wrapped with tarred flannel.

The working barrels are of metal, $1\frac{1}{4}$ inches thick, neatly bored out. This is preferred, in this case, owing to the hard nature of the coal, which if it got in would soon flute the barrel.

The buckets and clacks are of ordinary construction, graithed with leather; they are double-keyed, sneck and driving keys; they have both steel fall plates, $\frac{1}{8}$ inch thick, of soft steel, which are found to last three times as long as iron ones. The bucket sword is double hooped, and the clack bow is left on to avoid damage to the clack piece in case of a dropped bucket or broken spear, or in case it may have to be drawn up through pumps. The wind-bores are placed on the bottom, except that of the 24-inch sett. This sett if carried straight down the pit would have come exactly in the middle of the pit eye; to avoid this, after much discussion it was decided to put in a breeches piece with two legs, 15 inches diameter, as shown in Fig. 3. The snore pieces are on baulks, as when put in it was impossible, owing to a large feeder of water, to get down to bottom of sump. It was a matter for consideration whether two clacks, one in each branch, or one clack in the main pumps, which would have a long suction, should be put in; the latter plan was decided on, as the former would have needed a lot of the shaft to be taken out to get at the clacks; as it was, the shaft was much enlarged to get the legs in. The length of suction is 30 feet, a large amount, but no difficulty has been found in pumping, the sett being quite solid. It will be seen from Fig. 3 that the bend of the legs is very square, no doubt a rounder bend would have been better, but owing to having the hanging-on as high as possible the square form was adopted.

Governor.—The Napier cat governor is employed, and found to answer admirably (Figs. 4, 5, 6, and 7). In this governor two hollow discs, B and C, fitted with appropriate blades are placed face to face in a casing which is filled with water. One of these discs is driven by the engine by belt pulley E and spindle D, and the other oscillates and works the throttle valve.

The water in the revolving disc is thrown outward, forward, and sideways into the oscillating disc. The blades in the latter disc deflect the currents from an outward and forward direction into an inward and backward direction, and send the water back into the revolving disc.

This reversing of the motion of the water by the blades of the oscillating disc gives it a great tendency to revolve in the same direction as the other disc. This tendency is resisted by a chain, H, attached to a pulley on the disc till the strain on that chain is sufficient to lift a balance weight, K, which keeps the throttle valve open. When that strain is exceeded it shuts the throttle, and when it falls short the weight opens it. L M, Fig. 4, shows the lever connection to the throttle valve, and N steam pipe with valve.

Though this may look in some respects like a centrifugal governor, in this case a comparatively small velocity of disc is required to get up a much greater power than with any centrifugal arrangement, and the power developed is very remarkable when compared with the smallness of the discs and their velocities, whilst a sudden increase of velocity produces an almost instantaneous action on the throttle. So that the whole work may suddenly be taken off, with hardly a perceptible effect on the engine.

On one occasion, with 14-inch setts, the ball of the governor was seen to fall, the engine stopped, and then went quietly on; a man being sent down the shaft found a spear of one of the setts broken.

Almost the only wearing part is the spindle of the revolving disc, and there is no strain on it. The governor rope is made of strands of hide.

Indicator Tests.

North Side Engine.

In.		H.P.		L.P.		Total.
6	cut-off in H.P. cyl. I.H.P.	= 43·10	...	9·14	=	52·24 I.H.P.
18	„ „	= 48·10	...	9·63	=	57·74 „
30	„ „	= 57·12	...	16·65	=	73·77 „

South Side Engine.

In.		H.P.		L.P.		Total.
6	cut-off in H.P. cyl. I.H.P.	= 43·82	...	11·01	=	54·83 I.H.P.
18	„ „	= 53·27	...	15·34	=	68·61 „
30	„ „	= 57·48	...	20·56	=	78·04 „

Engines Combined.

In.			
6	cut-off in H.P. cylinder	Total I.H.P.	= 107·07
18	„ „	„	= 126·35
30	„ „	„	= 151·81

Boiler Test.

1 Lancashire boiler 30 feet by 7 feet 6 inches, double-flued.

Steam	70 lbs. per square inch.	
Total grate surface	=	36 square feet.
„ heating „	=	550 „
Heating surface per foot of grate	=	15·2 „
Total coal used in 12 hours	=	4,116 lbs.
Total small coal used in 1 hour...	=	343 „

BOILER TEST.—*Continued.*

Total I.H.P., as per diagrams, at normal rate of cut-off	=	107·07 I.H.P.
Coal per I.H.P. per hour	=	3·2 lbs.
Effective H.P. in water lifted (3 % being allowed for slip)	=	93
Effective H.P. per cent.	=	87
Coal per E.H.P. per hour	=	3·9 lbs.
Duty in millions of pounds per 112 lbs. of coal	=	60·3

The coal consumption being more than it should be, owing to the engines, which were made to pump 5,000 gallons of water per minute, having to pump at the present time about 2,000 gallons, it has been suggested, in order to reduce the power of the engines and boilers to the work likely to be required of them for some time: 1st. That liners should be put inside the high pressure cylinders, reducing the diameter from 19 to 17 inches, and that new pistons should be provided of the latter diameter; so that should there be at any time a great influx of water the liners could be withdrawn and the present pistons put in again, and the engine, if required, worked up to its full power. 2nd. That one engine should be used alone. This has been tried with a lessened consumption of 2·8 lbs. per I.H.P. but it is thought better to work two engines, except in case of need, owing to too much strain being put on one side.

Water Wheels.—The water from the pit not being suitable for boilers, and the river water eminently so, the feeder after leaving the adit is utilized to drive two water wheels, which pump from the river Tyne, a vertical height of 181 feet, through 500 yards of pipes. They are both over-shot wheels, the first one put in being 10 feet diameter and 2 feet wide; the second one 10 feet diameter and 4 feet wide; the centre arms and shrouding are of cast iron, the buckets and sole-plates of steel, and the shaft of wrought iron, 7 feet long and 4½ inches diameter. The smaller wheel works one double-acting cast iron pump, 5 inches diameter and 18 inches stroke; the larger one works two single-acting pumps, 8 inches diameter and 17 inches stroke, the pumps being placed opposite each other on a cast iron bed. They are driven off one crank pin fixed in a cast iron disc.

The feeder of water obtained from the large wheel working 12 strokes per minute is 78 gallons; the small one is only used whilst the other is standing.

It may be mentioned that a small water wheel, 4 feet diameter, is used underground for driving a small Schiele fan which ventilates an exploring heading 520 yards long.

In conclusion, it may be said, that nearly everything about engines, quadrants, etc., is kept in duplicate, for as there is practically no standage (the flatsheets being drowned in about six hours after stoppage of pumps), any accident is a very serious matter; but during the five years the new arrangement has been at work, there has been only one short stop, and then by working one quadrant and the two 14-inch setts the feeder was kept under till the necessary repairs were made.

The PRESIDENT said this paper was a very valuable one, and was now open for discussion. He would like to ask, so that they might be quite clear as to the comparisons drawn, what was the quality of coals used where the consumption was given?

Mr. J. K. GUTHRIE, in reply, said that the fuel used was half small and half unscreened. One boiler only was used in the experiments. Of course they had several boilers which were applied to other purposes as well, and they could only make short tests upon one boiler. The boiler used was of the Lancashire type, 30 feet long and 7 feet 6 inches diameter, with two tubes each 3 feet diameter.

The PRESIDENT said that the result of about 3·2 lbs. per horse-power was not so good as that obtained with Cornish engines, or other engines of a similar type. He noticed that bucket and not plunger pumps were used, probably in consequence of the standage being small. The engines used by the Lambeth and Chelsea Water Company were compound condensing engines, and he did not see any reason why Mr. Guthrie had not obtained a result equal to those of the water companies, a consumption of about 1·90 lbs. of coal per effective horse-power, and 1·60 lbs. per indicated horse-power. The difference—whether the coals were valuable or not—meant an important economy and an important difference in the wear and tear of boilers. It would be interesting to know whether the strata, which yielded the feeder, outcropped into the present or ancient Tyne bed, and whether such extraordinary feeders at that depth were traceable to water coming from the Tyne itself. He thought it was a matter of opinion as to whether the best type of engine had been adopted for dealing with such large quantities of water. He referred to Mr. J. B. Simpson's paper.* Considering the circumstances of this case, he inclined to the opinion that the double engines and L-legs, affording the opportunity of a perfect balance of the lifts, and, in the event of increased feeders, of a much higher speed, would, upon comparison, be found preferable to the Cornish engine.

Mr. A. L. STEAVENSON said the writer appeared to disparage the work done, but 3¼ lbs. per horse-power, with small coal, and under the conditions of a colliery, was a fairly good result. They could not expect such good results at a colliery as at a waterworks. It would be interesting if the writer could tell them how the quantity of water, multiplied by the vertical height it was raised, corresponded with the indicated horse-power. The pumping of water was a subject of the greatest interest to him personally, for he had recently been consulted, and requested to suggest the most suitable mode of pumping at least 3,000 gallons of water per minute, to a vertical height of 600 feet.

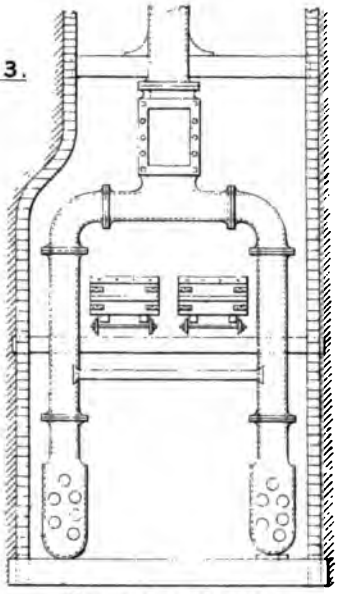
Mr. G. B. FORSTER said that the full duty might not be realized because the engine was said by the writer to be working at about 50 per cent. of its power. It was rather unfortunate that there was so little standage for the water, otherwise much better results might have been obtained at the full power of the engine. The

* North of England Transactions Vol. xix., page 206, for the fullest comparisons of the duties of various types.

Transactions

...tringham Colliery."

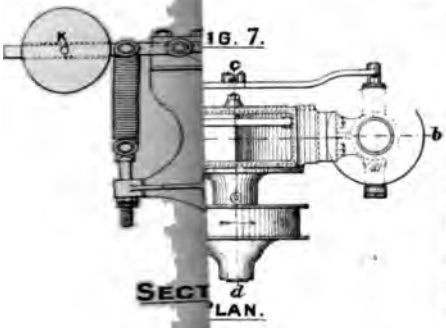
FIG. 3.



BREECHES PIPE PUMPS.

Scale 10 Feet to 1 Inch.

...IG. 7.



SECT... d ...LAN.

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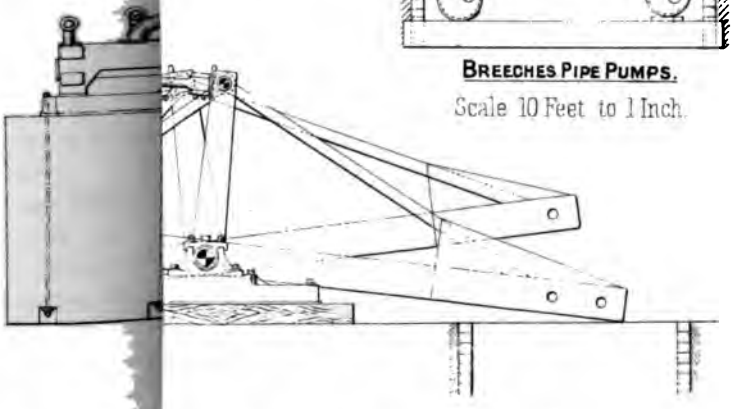
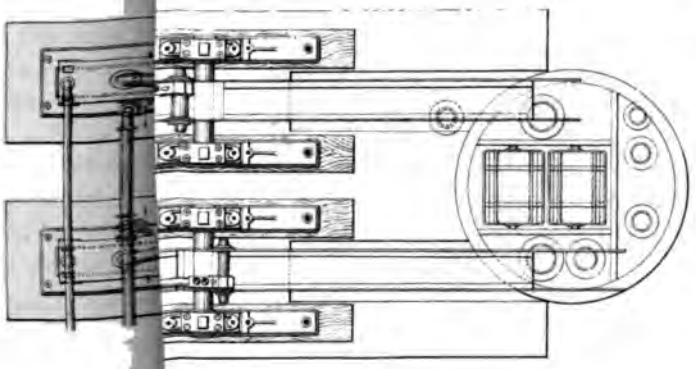




results recorded for the waterworks engines would be obtained from the use of best coal, and should not be compared with the results of this colliery engine, fired with a mixture of small and unscreened coal. The recorded temperature of the water did not seem to him to prove anything, because, beyond a certain depth, the rocks had a constant temperature which did not vary with the temperature of the surface. If the water did pass from the river, it would, no doubt, assume the temperature of the rocks before it passed into the mine. The temperature of the water would only denote the temperature of the strata through which it passed.

Professor J. H. MERIVALE said that Mr. G. B. Forster had drawn attention to the fact of water assuming the temperature of the strata through which it flowed, but Mr. Guthrie's observations seemed somewhat contradictory. The temperature of water pumped from a depth of 59 or 60 fathoms should be about 54 or 55 degrees Fahr. The temperatures were much lower than the strata could have had at any point except close to the surface on a cold day in the month of January. The observations seemed to prove that the feeder originated near the surface and was not derived from deep-seated water. It would be interesting if the experiments with the thermometers were continued so as to ascertain whether there was any connexion with the river.

Mr. A. L. STEAVENSON said the water pumped appeared to be measured over a weir. He always found that measuring over a weir was unsatisfactory, and gave higher results than if measured into a box. They would find that most trials of turbines which had been taken by water flowing over a weir were wrong. He did not think that the efficiency of any turbine exceeded 60 per cent., but results were recorded as high as 90 per cent. He always recommended that experiments as to the volume of water should be measured in a boiler, box, or other means, which gave true results, while only comparative results could be obtained from the flow over weirs.

Mr. THOMAS BELL (H.M. Inspector of Mines) asked what advantage was derived from having two wind-bores?

Mr. GUTHRIE—Under the circumstances, if the main pumps had been carried straight down, they would have covered the inlet to the cage. The two wind-bores straddle the pit.

Mr. W. C. BLACKETT asked if any other member had ever known a pump with such a vertical height of suction pipe as 30 feet? Had Mr. Guthrie observed any difference in the effects of the pump with variations in the height of the barometer, and had the working of the pump ever been affected when the barometer fell very low?

Mr. GUTHRIE said that they frequently worked with a lift of 32 feet when the water was low down. He had not observed the effects of a low barometer as referred to, but he would have pleasure in doing so, and he thanked Mr. Blackett for the hint. As regarded the consumption of fuel, he might say they were using their own

coal (an inferior Brockwell Seam, only worked for their brickworks and pit use), but he had not the slightest doubt he would have obtained a result much under 3 lbs. per indicated horse-power if they had used suitable coal.

Mr. THOMAS BELL said he would like to know the experience of others as to the use of spur gear for pumping, especially in the case of sinking pits. He had a personal objection to its use. Would it not be better to work direct?

Mr. GUTHRIE said he would not adopt spur gear if he erected another engine. If the spur gear failed then the entire engine was useless. In the present case, however, with a pair of engines, if one spur wheel gave way, the engine on the other side could be worked, and together with one 14-inch sett would keep the pit dry. The spur wheels were made in halves.

The PRESIDENT said there were many points of interest raised in the paper, especially the source of the feeder, which he hoped would be further investigated. He asked if it was not at one time proposed to dam the feeder back by some underground works?

Mr. GUTHRIE said he did not think that their feeder of water was derived from the river. In addition to difference of temperature the quality was quite different, the pit water being of a limey nature and totally unfit for boiler use, whilst the river water used for that purpose was taken from within 900 yards of the outcrop of the Cannel Seam in the present river bed. The damming back of the water had been suggested, but the works would have been of such magnitude that it was not gone on with. The quantity of water was measured into a box, 3 per cent. slip was found, and the effective horse-power in water lifted was 87 per cent.

Mr. G. B. FORSTER said it was very often a fallacy to suppose that the water found in a pit was derived from sources immediately above them. A case came under his notice the other day in which they were working coal under the sea, at a distance of about 1,000 yards seaward from low-water mark, and they got a feeder of pure, clear water, apparently free from salt, although all the other feeders in the district were brackish. The spring water feeder could not have been derived from the sea, and could only have reached the point where it was found under the sea, through a fissure, from a supply on the land. In Cheshire the source of the water was frequently many miles distant from the brine wells.

Mr. THOMAS BELL suggested that a section might be prepared showing the pit and the rise and dip of the strata from or to the River Tyne.

The vote of thanks, proposed by the PRESIDENT, and seconded by Mr. J. B. SIMPSON, was cordially adopted.

DISCUSSION UPON "AN INVESTIGATION AS TO WHETHER THE FUMES PRODUCED FROM THE USE OF ROBURITE AND TONITE IN COAL MINES ARE INJURIOUS TO HEALTH."

Dr. P. PHILLIPS BEDSON exhibited and explained the apparatus used in collecting the samples of air containing the fumes for experiment. He said that, as the report had not yet been issued to the members of the Institute, he would make a few remarks with regard to the general arrangements made, in attempting to answer the question referred to the committee as to whether the fumes from roburite, tonite, and gunpowder were injurious to health. All the experiments were made in the mine and under ordinary working conditions, and consequently the samples of the fumes obtained were diluted with air. The first difficulty met with in making such an investigation was to devise a method of collecting samples of the gases. Samples of air were collected at the places where the shots were fired, and in the intake and in the return of the district in which the experiments were made. There were samples taken in the intake and the return over a period of an hour or an hour and a half, and also in the working places taken immediately after the firing of the shot. At the intake, there was suspended midway in the gallery a zinc aspirator, having a capacity of about 600 cubic inches. This apparatus was first filled with water; the upper tube was filled with glass wool; and the lower opening closed by india-rubber tubing, the opening of which could be regulated by a screw clamp, so that the aspirator could be emptied of the water at a uniform rate in an hour or an hour and a half, as required. This sample of air was carefully examined for other gases than oxygen, nitrogen, and carbonic acid gases, the ordinary constituents of air. At the return, a similar series of observations was made, and in addition there was suspended a live mouse in a box to test the air for carbon monoxide gas. The blood of the mouse was afterwards examined by the spectroscope, and in only one instance did they find carbon monoxide gas by this method. The most important part of the investigation was the collection of the air in the place immediately after the firing of a shot, as the samples in the intake and return only afforded some idea of the vitiation produced in the district. The samples of air obtained after firing a shot were collected in brass cylinders of about 678 cubic inches capacity, provided at one end with two brass tubes to which stout india-rubber tubes were attached. Each cylinder was exhausted with a good air-pump, so as to give a vacuum of a fraction of an inch of mercury. With the exhausted cylinder a short distance from the working place the firing of the shot was awaited, then hastening into the place, and opening the cylinder by unscrewing the clamp the fumes were drawn into the vacuous cylinder. The samples of the gases were then transported to the laboratory for examination. The investigation had shown that in the case of each of the explosives, carbon monoxide, which is not a constituent of ordinary air, was produced. This gas had been found in various proportions in the fumes of all three explosives. It was not strange that it should be found

after the firing of gunpowder, since laboratory experiments with gunpowder had already shown that carbon monoxide was a product of the explosion of gunpowder. The presence of carbon monoxide had been shown by a very delicate test, in which a solution of palladium chloride was used. The report, after giving the statement of the actual results of the analysis, contained a theoretical consideration of the results which should be obtained by firing roburite, tonite, and gunpowder in a mine. The result of firing an explosive in a mine was to add to the air the gaseous and solid products formed by the explosive. To form some idea of the vitiation produced by these different explosives the proportion of gas produced by 7 ozs. of tonite, roburite, and gunpowder had been calculated. Next assuming that these gases were mixed with 540 cubic feet of air, and the following statement abstracted from the report represented the results of such calculations:—

	Gunpowder.	Roburite.	Tonite.
Volume of gases produced by the explosion of 7 ounces., in cubic feet, ...	1·92	3·02	2·43
Mixture produced with air:—			
Nitrogen	78·96	79·00	78·879
Oxygen	20·77	20·74	20·788
Carbonic acid	0·21	0·23	0·333
Carbon monoxide	0·05	—	—
Sulphuretted hydrogen	0·01	—	—
Hydrochloric acid	—	0·03	—

He wished to refer to another point. In the report a statement of the experimental results was given which was arrived at by taking the results of the analyses of the samples of air in the intake and return, as well as of those collected at the place immediately after the firing of the shot, and making an average of the various samples collected. He had, so far, dealt entirely with gaseous products in the report, but it must be remembered that the fumes from gunpowder contained a large amount of solid matter, about 55 per cent., and it was shown by Captain Noble and Sir Frederick Abel that these were solids of a very complex nature. It had always been considered that one of the dangers of the use of roburite was that after its explosion some particles of undecomposed nitrobenzene might be found in the air; but in these experiments no evidence of the presence of nitrobenzene had been obtained, save that its characteristic odour had been observed on several occasions.

The PRESIDENT asked whether 1 in 10,000 parts of carbon monoxide could be distinguished on paper saturated with palladium chloride?

Dr. BEDSON said that paper saturated as he had described could certainly be used to distinguish small percentages of carbon monoxide gas by using considerable volumes of the air.

The PRESIDENT—You judged from the various shades?

Dr. BEDSON—No. In actual practice the gas was passed through a tube containing a solution of palladium chloride. By using equal volumes of air the depth of shade might be used to estimate the proportion of carbon monoxide.

Mr. T. J. MURDAY described his "Fire-Damp Detector" as follows:—

FIRE-DAMP DETECTOR.

By T. J. Murday.

Fig. 1 (Plate XLIII.) shows the apparatus fitted up with battery and alarm bell. In this case the model instrument is worked by four small dry cells. A push A is shown at the top of the case, which when depressed closes the electrical circuit through the platinum wires, etc. By means of the thumbscrew B, near the upper part of the case, the alarm pointer C can be set to any division on the scale, so that on the real pointer D rising on the scale, and making contact with this adjustable pointer, the bell E is rung. In searching the galleries of a mine for gas all that need be done is to set the alarm pointer to 1 per cent. or under before commencing the search, and occasionally to press the push (the push should never be kept down for a longer period than one second). So long as no fire-damp up to 1 per cent. (or wherever the pointer is set to) is present in the air the bell E will not be rung; but on the percentage reaching that amount the bell will immediately sound on the push being pressed.

Fig. 2 (Plate XLIII.) shows the mechanical arrangement. It will perhaps be best understood if it be likened to a differential metallic thermometer. It consists essentially of a pair of platinum wires, A and B. These wires are kept in tension by means of a system of L-levers C C^1, and springs D D^1, connected by the rack E. The movements of the rack are communicated to the pointer F, through the pinion I. The pointer F stands at zero so long as the temperature of both platinum wires is the same; but on one wire being more heated than the other a deflection of the pointer at once takes place. One platinum wire A is encased in an air-tight cylinder with a flexible diaphragm G, at the lower end, so that the rod-extension H, to which this platinum wire is attached, may be free to move as the platinum expands and contracts. The other platinum wire B is exposed to the free air, but at the same time is surrounded by a wire gauze to avoid ignition of the gaseous mixture, which may at times be present in the case.

When the push A (Fig. 1, Plate XLIII.) is pressed a current sufficient to heat the platinum wires to about 200 degs. Fahr. passes through them; they both expand equally, and no deflection of the pointer takes place; but if a small quantity of gas be present around the exposed platinum wire B combustion takes place, the wire B heats perceptibly more than the other, and the pointer F is deflected in proportion as there is more or less fire-damp present in the air around the instrument. The test is made instantly, very little current is used, and the attached bell arrangement makes it unnecessary for the person using the searcher to be constantly inspecting the dial.

On the motion of the Chairman a vote of thanks was accorded to Mr. T. J. Murday.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

ANNUAL GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE, AUGUST 1ST, 1891.

MR. WILLIAM COCHRANE, RETIRING PRESIDENT, IN THE CHAIR.

The CHAIRMAN said the first business was to appoint scrutineers for the examination of the balloting papers, and Messrs. J. W. Fryar, H. Jepson, C. J. Murton, and G. F. Bell, who had kindly undertaken the duty, were unanimously elected scrutineers.

The SECRETARY read the minutes of the last meeting, and reported the proceedings of the Council.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. Ernest F. Ayton, Mining Engineer, El Botè Mining Negociacion, Zacatecas, Republic of Mexico.

Mr. Charles Spearman Carnes, Colliery Manager, Peases' West Colliery, Crook.

Mr. Robert Middleton, Hydraulic Engineer, Sheep Scar Foundry, Leeds.

Mr. John Palmer Stukley Samborne, Mining Engineer, Timsbury House, Bath.

Mr. Samuel Hare, Mining Engineer, Brymbo Collieries, Wrexham, North Wales.

Mr. Wm. Hay, Jun., Manager of Mines, Wood View House, Stanton, Burton-on-Trent.

Mr. George Hurst, Mining Engineer, 58, Eldon Street, Newcastle-upon-Tyne.

ASSOCIATE MEMBER—

Mr. Edward Ellison Bigge, Secretary, General Mining Association, Blomfield House, London Wall, London, E.C.

STUDENTS—

Mr. David Douglas, Mining Student, Trimdon Grange, R.S.O., Co. Durham.

Mr. Nelson Ashbridge Simpson, Student Mining Engineer, North Navigation Collieries, Maisteg, Bridgend, South Wales.

Mechanical Institution of Mining Engineers
Transactions 1890-91.

To illustrate Mr. T. J. Murday's "Fire-Damp Detector."

FIG. 1.

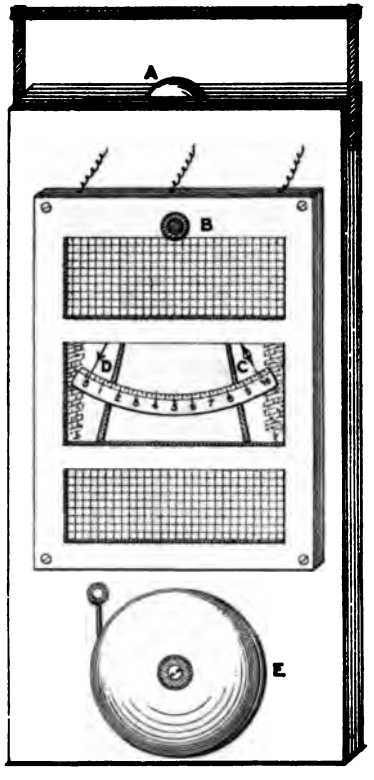
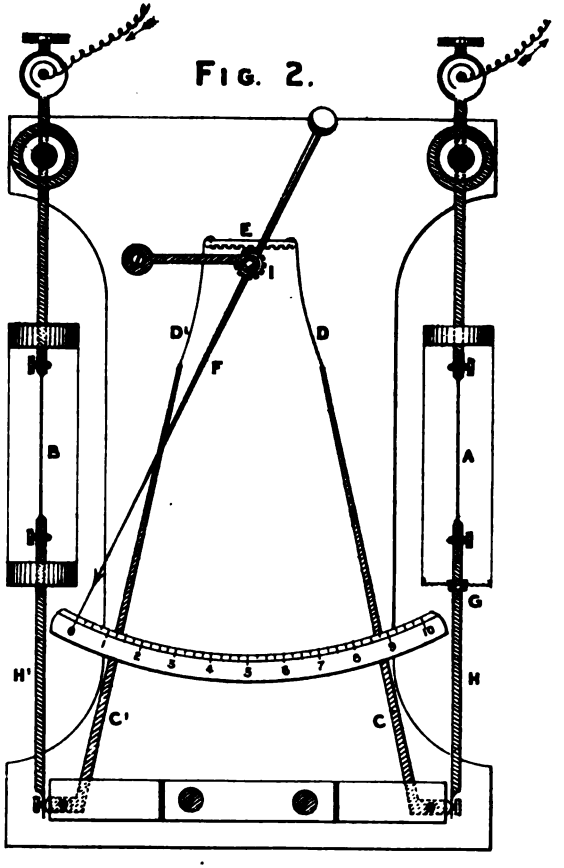


FIG. 2.



The following gentlemen were nominated for election :—

MEMBERS—

Mr. Arthur Payne Gallwey, Mining Engineer, P.O., Box 138, Johannesburg, Z.A.R.

Mr. Ernest Seymour Wood, Mining Engineer, South Hetton, Sunderland.

Mr. Ernest Williams, Civil and Mining Engineer, Assoc. Mem. Inst. of C.E., Johannesburg, South Africa.

ASSOCIATE MEMBERS—

Mr. Henry Heath Cochrane, Colliery Owner, Eshwood Hall, Durham.

Mr. William Percy Cochrane, Colliery Owner, 6, Tankerville Terrace, Newcastle-upon-Tyne.

Mr. James John Joicey, Colliery Owner, Sunningdale Park, Berkshire.

Mr. Frederick Richter, Merchant, Osborne Villas, Newcastle-upon-Tyne.

ASSOCIATE—

Mr. George William Minto, Deputy Overman, Heworth Colliery, Heworth-upon-Tyne.

AWARDS FOR PAPERS.

The Secretary read the following list of papers for which prizes had been awarded to the authors :—

YEAR 1885-1886	
NAME.	TITLE OF PAPER.
George J. Binns	Coal Mining in New Zealand.
J. D. Kendall	The Iron Ores of the English Secondary Rocks.
J. M. Liddell and J. H. Merivale	Transmission of Power by Steam.
E. H. Liveing	Transylvanian Gold Mining.
YEAR 1886-1887.	
M. Walton Brown ...	On a Form of Apparatus for the Rapid Determination of Specific Gravities of Bodies.
Edward Halse	On the Occurrence of Manganese Ore in the Cambrian Rocks of Merionethshire.
A. L. Steavenson	On the System of Working Ironstone at Lumpsey Mines by Hydraulic Drills.
Henry White	Remarks on a Further Discharge of Lightning at West Thornley Colliery, near Tow Law, on October 21, 1886.

YEAR 1887-1888.	
Name.	**Title of Paper.**
John Allan...	The Pyrites Deposits of the Province of Huelva.
P. Phillips Bedson ...	A Contribution to our Knowledge of Coal-Dust.
Hugh Bramwell	Notes on the Horizon of the Low Main Seam in a Portion of the Durham Coal-field.
M. Walton Brown ...	A further attempt for the Correlation of the Coal Seams of the Carboniferous Formation of the North of England, with some Notes upon the probable duration of the Coal-field.
A. S. Herschel	On an Improved Form of Seismoscope.
C. J. Murton	Notes on the Tkiboulli Coal-field (Caucasus).
YEAR 1888-1889.	
W. Armstrong, Jun., and W. J. Bird	The Economical Working of Steam Boilers at Collieries.
Bennet H. Brough ...	Outbursts of Gas in Metalliferous Mines.
M. Walton Brown ...	The Pieler Spirit Lamp as a Fire-damp Indicator.
Charles Z. Bunning ...	Coal Mining at Warora, Central Provinces, East India.
T. L. Elwen	An Account of Experiments on the Resistance to Air Currents in Mines.
J. M. Liddell	The Gold-fields of the Valley of De Kaap, Transvaal, South Africa.
T. O. Robson	Notes on the Variations in the Faulting of Coal, observed in the Action of the same Series of Faults in Three Seams at Redheugh Colliery.
YEAR 1889-1890.	
D. H. Bayldon	The Hauraki Gold Mining District (Northern Section) Auckland, New Zealand.
T. E. Forster and H. Ayton	Improved Coal Screening and Cleaning.
S. Tate	Winding, Banking Out, and Screening Plant at East Hetton Colliery.
YEAR 1890-1891 (Part of).	
David Burns	On the Bending of Beds near Veins.
E. Halse	Some Banket Deposits of the Gold Coast, West Africa.

The Annual Reports of the Council and Finance Committee were read as follows:—

ANNUAL REPORT OF THE COUNCIL.

The following table shows the membership during recent years:—

	August 1st.			
	1888.	1889.	1890.	1891.
Honorary Members	27	26	25	24
Members	603	569	556	535
Associate Members		28	27	29
Associates		3	25	28
Students	48	43	35	36
Subscribing Collieries	16	18	18	18
Totals	694	687	686	670

The maximum number of Members was attained on August 1st, 1877, viz:—23 Honorary Members, 792 Members, 142 Students, and 14 Subscribing Collieries, a total of 971 Members.

The effects of the Bye-Laws which came in force in 1889 are now being experienced, and there is every reason to hope that they will ultimately lead to a steady and continued increase in the membership. The class of Associates, consisting of persons occupying subordinate positions in engineering, has been successfully initiated, and must eventually tend to the efficiency of the Institute.

The Federated Institution of Mining Engineers has now completed the second year of its existence, during which there have been three general meetings—Nottingham on September 24th and 25th, 1890; Newcastle-upon-Tyne, January 21st and 22nd, 1891; and London, May 28th and 29th, 1891. These meetings have been attended by a large number of the members of the four Federated Institutes, and there has been a marked increase in the number of papers read at these meetings. In addition to receiving the papers read before this Institute, the members now receive, without extra cost, the papers read at the meetings of the Federated Institution of Mining Engineers, and of the Chesterfield and Midland Counties Institution of Engineers, the Midland Institute of Mining, Civil, and Mechanical Engineers, and the South Staffordshire and East Worcestershire Institute of Mining Engineers. With continued attention of the Federated Institutes, the Federated Institution of Mining Engineers ought eventually to include all of the institutes interested in mining, metallurgical, and mechanical engineering.

The Committee on Mechanical Ventilators has not completed its report owing to the mass of calculations required in the reduction of the experiments, but there is every reason to hope that it will be completed at an early date.

The Committee on "Flameless" Explosives hopes to commence its practical experiments shortly. Messrs. W. J. Bird and M. Walton Brown have ably trans-

lated the "Report of the French Commission on the Use of Explosives in Mines," for the use and information of the members of the Committee, and it has been issued to the members of the Institute by order of the Council, who are of opinion that this volume is a valuable addition to the publications of the Institute. Mr. M. Walton Brown was present, on the request of the Committee, at some experiments on explosives at Cymmer Collieries, and his interesting report was communicated by the Committee to the members.

The "Borings and Sinkings" are now approaching completion, and a fifth volume will be published during the ensuing year.

The Library of the Institute continues to be maintained in an efficient state, and the members in the vicinity are reminded that the books and weekly engineering papers are available daily from 10 a.m. to 5 p.m., whilst those at a distance may avail themselves of the Library by communication with the Librarian.

Material changes have taken place in the officers of the Institute through the death of Mr. F. Gosman, on September 12th, 1890, after many years of faithful attention to the interests of the Institute, and through the retirement of the Secretary, Professor Lebour, in January last. The Council trust that the appointment of their successors will tend to the efficient conduct of the business of the Institute. Mr. M. Walton Brown has been appointed Secretary and Mr. Reginald Guthrie, Treasurer.

The Institute has again been placed on the list of corresponding societies of the British Association, and the Council have appointed Professor J. H. Merivale, M.A., to act as their delegate at the ensuing meeting at Cardiff.

The Council deeply regret the death during the year of Mr. John Marley, Past-President, and of Mr. James Willis, H.M. Inspector of Mines, Vice-President—two gentlemen who have at all times contributed every assistance to the well-being of the Institute.

The papers contributed during the year are as follow:—

"Experiments with Explosives used in Mines." By Mr. M. Walton Brown.

"On the Bending of Beds near Veins." By Mr. David Burns.

"Some Banket Deposits of the Gold Coast, West Africa." By Mr. Edward Halse.

"Experiments with Carbonite." By Messrs. M. Walton Brown and William Foggin.

"The Waddle Patent (1890) Fan." By Mr. M. Walton Brown.

"On the Present Position of the Question of Transmission of Power." By Mr. A. L. Steavenson.

"On the Pumping Arrangements at Eltringham Colliery." By Mr. J. Kenneth Guthrie.

"On a Duplex Arrangement of Centrifugal Ventilating Machines." By Mr. W. Cochrane.

In concluding their fortieth annual report, while the Council congratulate the members upon the present position of the Institute, they ask them to bring its claims and advantages before others.

FINANCE REPORT.

The income for the year 1890–1 amounted to £1,790 9s. 0d.; deducting from thi a sum of £200 received from the Coal Owners' Associations towards the costs to be incurred by the Explosives Committee, shows the ordinary income to be £1,590 9s. 0d., an increase of £80 14s. 10d. over the preceding year.

The total receipts for subscriptions and arrears amounted to £1,302 14s. 0d., an increase of £93 8s. 4d. The amount of subscriptions in arrear beyond one year now amount to £141 15s. 0d. The sum of £180 12s. 0d. has been struck off during the year as irrecoverable.

The total expenditure during the year has amounted to £2 232 8s. 3d., which is considerably in excess of that of the previous year, but during this year, two years' payments to the Federated Institution have been made.

THE TREASURER IN ACCOUNT WITH THE NORTH OF ENGLA

DR. *For the Year end*

July 16, 1890.	£ s. d.	£ s.	
To Balance at Bankers	510 7 10		
„ „ in hand	87 6 4		
		597	14
„ Dividend of 3½ per cent. on 134 Shares of £20 each in the Institute and Coal Trade Chambers Co., Ltd., for the half year ending December, 1890	93 16 0		
„ „ ending June, 1891	93 16 0		
	187 12 0		
„ Interest on Investments with the River Tyne Commissioners	73 2 6		
		260	14
To EXPLOSIVES COMMITTEE—			
Subscription from Durham Coal Owners' Association	150 0 0		
„ „ Northumberland „ „	50 0 0		
		200	0
To SUBSCRIPTIONS FOR 1890-91 AS FOLLOWS:—			
403 Ordinary Members ... ... @ £2 2s.	846 6 0		
2 Life Members	50 0 0		
23 Associate Members ... ... @ £2 2s.	48 6 0		
19 Associates ... ... @ £1 1s.	**19 19 0**		
18 Students ... ... @ £1 1s.	**18 18 0**		
1 Life Member ... ... (Balance)	**17 18 0**		
4 Associates ... ... @ £2 2s.	**8 8 0**		
4 New Members ... ... @ £2 2s.	**8 8 0**		
5 New Associates ... ... @ £1 1s.	**5 5 0**		
5 New Students ... ... @ £1 1s.	**5 5 0**		
1 New Associate Member ... ... @ £2 2s.	**2 2 0**		
	1,030 15 0		
To SUBSCRIBING COLLIERIES, VIZ.:—			
Ashington £2 2 0			
Bridgewater Trustees 6 6 0			
North Hetton 6 6 0			
Londonderry Collieries 10 10 0			
North Brancepeth 2 2 0			
Stella 2 2 0			
Victoria Garesfield 2 2 0			
Wearmouth 4 4 0			
	35 14 0		
	1,066 9 0		
To Arrears	**217 7 0**		
		1,283	**16**
„ Subscriptions Paid in Advance		**18**	**18**
„ Sale of Publications, per Secretary	**26 4 6**		
„ „ „ per A. Reid, Sons & Co.	**0 16 0**		
		27	**0**
		£2,388	**3**

INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

July 31st, 1891. CR.

July 23, 1891.	£	s.	d.	£	s.	d.
By Publishing and Stationery Accounts, viz.:—						
A. Reid, Sons & Co.	168	7	2			
Lambert & Co.	82	18	4			
				251	5	6
„ Books for Library	50	15	2			
„ Printing (Annan & Swan)	5	7	6			
„ Abstracts of Foreign Papers	21	12	6			
„ Incidental Expenses	156	2	2			
„ Sundry Accounts	33	5	9			
„ Travelling Expenses	41	13	0			
„ Salaries, etc.	419	16	3			
„ Clerks' Wages	127	13	4			
„ Reporter's Salary	12	12	0			
„ Rent	97	4	8			
„ Rates and Taxes	19	7	10			
„ Insurance	9	4	11			
„ Furnishing, etc.	4	16	6			
„ Coals, Gas, and Water	22	11	7			
				1,022	3	2
„ Guibal Memorial	25	0	0			
„ Expenses of Federated Institute Meeting in Newcastle	45	3	0			
„ Explosives Committee	6	14	0			
„ Fan Committee	5	1	0			
„ Exors. of late F. Gosman	75	0	0			
By Federated Institution of Mining Engineers—						
Two Years' Calls £1,025 5 0						
Less—Payments made on behalf of the Federated Institution, as per last year's General Statement 223 3 5						
	802	1	7			
				958	19	7
By Balance at Bank	71	2	8			
„ „ in hand	84	12	3			
				155	14	11
				£2,388	3	2

Audited and found correct.

JOHN G. BENSON,
CHARTERED ACCOUNTANT.

Newcastle-upon-Tyne,
31st July, 1891.

Dr.				The Treasurer in Account
		£ s. d.	£ s. d.	
To 563 Members,				
23 of whom are Life Members.				
—	Life Members (2)	50 0 0		
540	540 @ £2 2s.	1,134 0 0		
			1,184	0 0
To 29 Associate Members,				
4 of whom are Life Members.				
—	Life Member (balance)	17 18 0		
25	25 @ £2 2s.	52 10 0		
			70	8 0
To 4 Associates @ £2 2s.		8 8 0		
28 „ @ £1 1s.		24 3 0		
			32	11 0
27				
To 36 Students @ £1 1s.		.....	37	16 0
To 5 New Members @ £2 2s.		.....	10	10 0
To 2 New Associate Members @ £2 2s.		.....	4	4 0
To 5 New Associates @ £1 1s.		.....	5	5 0
To 5 New Students @ £1 1s.		.....	5	5 0
To Subscribing Collieries		.....	92	8 0
			1,442	7 0
To Arrears, as per Balance Sheet 1889-90		539 14 0		
Less—Struck out as Irrecoverable		180 12 0		
			359	2 0
To Subscriptions Paid in Advance		.....	18	18 0
			£1,820	7 0

WITH SUBSCRIPTIONS, 1890-91. CR.

		PAID. £ s. d.	UNPAID. £ s. d.
By 2 Life Members, paid		50 0 0	.....
By 1 Life Member, paid (balance)		17 18 0	.....
By 403 Members, paid	@ £2 2s.	846 6 0	.....
By 111 „ unpaid	@ £2 2s.	.....	233 2 0
By 2 „ transferred to Hon. Members		.....	4 4 0
By 13 „ struck off	@ £2 2s.	.....	27 6 0
By 5 „ resigned	@ £2 2s.	.....	10 10 0
By 6 „ dead	@ £2 2s.	.....	12 12 0
540			
By 23 Associate Members, paid	@ £2 2s.	48 6 0	.....
By 1 „ Member, unpaid	@ £2 2s.	.....	2 2 0
By 1 „ „ resigned	@ £2 2s.	.....	2 2 0
25			
By 4 Associates, paid	@ £2 2s.	8 8 0	.....
By 19 „ „	@ £1 1s.	19 19 0	.....
By 4 „ unpaid	@ £1 1s.	.....	4 4 0
27			
By 18 Students, paid	@ £1 1s.	18 18 0	.....
By 16 „ unpaid	@ £1 1s.	.....	16 16 0
By 2 „ struck off	@ £1 1s.	.....	2 2 0
36			
By 4 New Members, paid	@ £2 2s.	8 8 0	.....
By 1 New Member, unpaid	@ £2 2s.	.....	2 2 0
5			
By 1 New Associate Member, paid	@ £2 2s.	2 2 0	.....
By 1 „ „ unpaid ...	@ £2 2s.	.....	2 2 0
2			
By 5 New Associates, paid	@ £1 1s.	5 5 0	.....
By 5 New Students, paid	@ £1 1s.	5 5 0	.....
By Subscribing Collieries, paid		35 14 0	.....
„ „ „ unpaid		.....	56 14 0
		1,066 9 0	375 18 0
By Arrears Paid		217 7 0	.....
„ „ Unpaid		.....	141 15 0
By Subscriptions paid in advance		18 18 0	.....
		£1,302 14 0	517 13 0
			1,302 14 0
			£1,820 7 0

General Statement, July 23rd, 1891.

Liabilities.	£	s.	d.
Subscriptions paid in Advance	18	18	0
Capital	11,703	19	11
	£11,722	17	11

Audited and found correct (Share Certificates and Bonds produced).

JOHN G. BENSON,
Chartered Accountant.

Newcastle-upon-Tyne,
31st July, 1891.

Assets.	£	s.	d.	£	s.	d.
Balance of Account at Bankers	71	2	8			
„ in Treasurer's hands	84	12	3			
				155	14	11
134 Shares of £20 each in the Institute and Coal Trade Chambers Co., Ltd.	.....			2,680	0	0
Invested with River Tyne Commissioners ...	.....			2,000	0	0
Arrears of Subscriptions	.....			517	13	0
Value of 546 Bound Volumes of Transactions, @ 11s. 6d.	313	19	0			
„ 4,477 Sewn do., @ 9s.	2,014	13	0			
„ 2,405 Unbound Parts, @ 2s.	240	10	0			
„ 78 Copies Mr. T. F. Brown's Map, @ 5s.	19	10	0			
„ 376 Copies of Index, Vols. 1-25, @ 3s.	56	8	0			
„ 757 Copies of Fossil Illustrations, @ 12s. 6d.	473	2	6			
„ 850 Copies of Catalogue of Fossils, @ 5s.	212	10	0			
„ 1,500 Copies of Borings and Sinkings (Vol. I. in Sheets)	300	0	0			
„ 281 Do., Vol. I., @ 2s. 6d.	35	2	6			
„ 308 Do., Vol. II., @ 5s.	77	0	0			
„ 326 Do., Vol. III., @ 5s.	81	10	0			
„ 441 Do., Vol. IV., @ 5s.	110	5	0			
„ Sheets of Do., Vol. V., unpublished ...	65	0	0			
„ 255 Copies of Library Catalogue, @ 5s.	63	15	0			
„ 111 Copies of Report of French Commission on Explosives, Part I., @ 5s.	27	15	0			
„ 137 Do. Do. Part II., @ 5s.	34	5	0			
„ 177 Do. Do. Part III., @ 5s.	44	5	0			
				4,169	10	0
„ Office Furniture and Fittings ...	450	0	0			
„ Books and Maps in Library	1,750	0	0			
				2,200	0	0
				£11,722	17	11

The CHAIRMAN, in moving the adoption of the Annual Report of the Council and of the Finance Committee, commented upon the financial results of the year, and said that those who could inculcate the idea of prompt payment of subscriptions among the members and who would adopt the same themselves would relieve the Institute of a great deal of trouble in the secretarial department and keep them, as they ought to be, well up in funds. The Council hoped that another year would find them in a much better financial condition, but this, however, would depend on the number of members being maintained. No doubt, as the report said, in referring to the 971 members in 1877, there were causes to account for the loss of members since then; one reason was the great competition in regard to the mechanical engineering element by kindred institutions. The establishment of the North-East Coast Institution of Engineers and Shipbuilders had taken a large number of those members who were purely mechanical engineers and not interested in mining subjects. But it must be remembered that, being the parent Institute of the Federated Institution which they had joined, and which gave them the advantage of having the papers of all the other districts embodied in the Transactions (so that they were not dependent on themselves altogether for papers on mining matters), it must not be otherwise written of them than that they felt the greatest responsibility on themselves to keep the foremost in all they did and the papers they read, so as not to lose that pre-eminence which, he maintained, they had held to the present time, and which, in becoming amalgamated with the Federated Institution, it behoved them to strain every nerve to maintain. He thought there was only one other matter on which he might say a word or two, and that was as to the desirability of better attendances at the general meetings. There was an enormous amount of good work done by committees—silent work, the results of which they could only see when it was printed in the Transactions; work done in committees was no doubt better than that done in ordinary meetings in delivering one's self of set speeches, but from the earnestness with which matters were discussed and the benefit that was got from knocking their opinions against each other, in public meetings they should feel that the attendances were not as satisfactory as they should be, and it behoved the Council to enquire whether the menu was good enough. He had known the history of this Institute for thirty-four years and certainly the attendances formerly were very much larger than now. He hoped that in the reign of his successor they would inaugurate something by which to secure larger attendances and that valuable discussions would arise on the papers read. He then moved the adoption of the reports of the Council and of the Finance Committee.

Mr. J. B. SIMPSON seconded the adoption of the reports, which was put to the meeting and carried unanimously.

REPRESENTATIVES ON THE COUNCIL OF THE FEDERATED INSTITUTION OF MINING ENGINEERS.

The SECRETARY reported that this Institute was entitled to seventeen representatives on the Council of the Federated Institution, the Chesterfield Institution to seven, the Midland to five, and the South Staffordshire to three. The Council recommended the re-election of the representatives appointed last year, together with Messrs. H. Lawrence and Professor J. H. Merivale, instead of Messrs. John Marley and Jas. Willis, who had died during the year, and of himself, who would attend as their Secretary.

Mr. STRATTON remarked that three names were withdrawn from the list and only two substituted.

The SECRETARY explained that, by the alteration of the rules of the Federated Institution, they were now only entitled to seventeen elected representatives on the Council, instead of the thirteen elected and four co-optated members of Council under the old rules.

The CHAIRMAN—Then, there are two vacancies to-day, and the Council recommend the re-election of the old representatives, together with Mr. Lawrence and Professor Merivale.

This resolution was put to the meeting and unanimously agreed to.

The representatives of the Institute for the ensuing year are as follows:—

W. Armstrong, Esq.	Thos. Douglas, Esq.
W. Armstrong, Jun.. Esq.	G. B. Forster, Esq.
Sir Lowthian Bell.	G. C. Greenwell, Esq.
Thos. J. Bewick, Esq.	Henry Lawrence, Esq.
Robt. F. Boyd, Esq.	Geo. May, Esq.
M. Walton Brown, Esq.	Prof. Merivale.
Wm. Cochrane, Esq.	J. B. Simpson, Esq.
Jno. Daglish, Esq.	A. L. Steavenson, Esq.
David Dale, Esq.	Lindsay Wood, Esq.

Mr. COCHRANE read the following paper, "On a Duplex Arrangement of Centrifugal Ventilating Machines":—

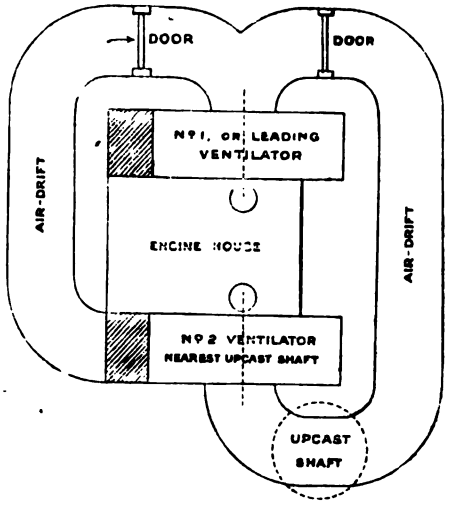
ON A DUPLEX ARRANGEMENT OF CENTRIFUGAL VENTILATING MACHINES.

By W. Cochrane.

In the course of an investigation with the late Mr. J. J. Atkinson, H.M. Inspector of Mines, in 1868, into the working of two Guibal ventilators at the Duffryn Collieries in South Wales, some interesting results were obtained, and a novelty was established in the application of two centrifugal machines, which it seems to the writer may be worthy of imitation under special circumstances. The ventilators, 30 feet diameter, were erected side by side, the two engines, 24 inches diameter and 24 inches stroke, being placed in a house between the ventilators, and a separate drift, but of different sectional area, from the upcast shaft was carried to each of the inlets.

The ventilation of the colliery was represented by about 80,000 cubic feet of air per minute, with a water-gauge of about 1·60 inches at the surface, and each ventilator was capable of producing this at a speed of about 58 revolutions per minute.

If the ventilators were run together at this same speed there was no important variation in volume, but a slight alteration in water-gauge, which was attributed to the different conditions of the two drifts from the upcast shaft.



The water-gauge, as is well known, is dependent on the velocity of the periphery of a centrifugal action ventilator; the only benefit from running two together as compared with one would arise from the lessened resistances encountered by the air in its passage through two surface-drifts and two ventilators at lower speeds than that with which the whole quantity would pass through a single drift and a single ventilator (it would be a very small amount), provided the one drift was of proper sectional area and the blades of sufficient breadth, with the outlet shutter properly adjusted—this small benefit would be discounted by the extra friction due to two engines and ventilators instead of one,

It was not considered safe to put the ventilators up to any higher speed for permanent work in order to obtain the increased ventilation which was required. The suggestion of the late Mr. J. J. Atkinson was to arrange the ventilators to work in duplex or tandem form, so that having expended the work of one, equal to circulating 80,000 cubic feet under 1·60 inches, the other should take up this volume of air at its decreased tension and impart to it a second equal work.

By this arrangement it would be possible to apply double the power through the two engines, and as the quantities of air are proportional to the cube roots of the powers circulating them in the same mine this was estimated to afford $\sqrt[3]{\frac{2}{1}} = 1{\cdot}26$, or 26 per cent. more air at the same speed of the ventilators. The water-gauge at the surface for this increased volume would be $\frac{126^2}{100^2} = 1{\cdot}5876$, or 58·76 per cent. higher than that existing, involving the increased speed of a single ventilator by 26 per cent., if that had been deemed the proper course; but the liability to heating and breakage, arising from high speeds of ventilators of large diameters where continuous working is a necessity, precluded such a recommendation; otherwise the increased speed, and the resulting higher water-gauge and volume of air, would have been obtainable by the single ventilator or the two working together side by side by the expenditure of about the same increased steam power, either in one cylinder or divided between the two.

The whole of the air from the upcast shaft was carried along one drift only to one of the ventilators, and at the foot of the chimney of this ventilator a drift was formed to connect with the inlet of the second ventilator, the air thus passing through the second ventilator and up its chimney into the open atmosphere. Suitable air-tight doors in the two drifts from the upcast, and at the foot of the chimney of the first ventilator were arranged so as to afford full opportunity of experiment.

Preliminary tests had been made with small cupola fans before proceeding to the important expenditure required in the above arrangement. They indicated that the estimated result would agree with the theoretical considerations due to the additional imparting of power by each additional fan, not only in exhausting from a mine, but also in producing accumulated pressure as a forcing fan.

The immediate ventilation required involved a considerably higher water-gauge —nearly double—and therefore, a corresponding increase in the effective pressure of steam in the engine cylinders was necessary. The air to be put in circulation would thus be $\frac{\sqrt{2}}{\sqrt{1}} = 1{\cdot}4142$, or 41·42 per cent. increase. Allowing for the greater resistances due to the air passing through two ventilators instead of one, it was estimated that one-third larger volume of air would be obtained in practice at the same speed of each ventilator by this duplex arrangement.

To have arrived at a similar result with one ventilator, would have required a speed of 41·42 per cent. higher than that at which it was running.

The works to carry out the suggestion having been executed, the following experiments were made to test the results.

1st. The two ventilators, exhausting on the duplex or tandem system, each making 60 revolutions per minute, yielded 108,479 cubic feet of air under a water-gauge at the inlet of the ventilator nearest to the upcast of 2·80 inches, and near the inlet of the leading ventilator of 1·10 inches.

2nd. The nearest ventilator to upcast, blowing through the leading ventilator (stationary), gave 79,218 cubic feet with a water-gauge at its inlet of 1·10 inches, and near the inlet of the leading ventilator of ·80 inches.

3rd. The leading ventilator, drawing through the nearest to upcast (stationary). gave 81,405 cubic feet with a water-gauge of 1·40 inches at the inlet of the latter, and of 1·75 inches near the inlet of the former.

4th. The ventilator nearest to upcast, working with separate drift from upcast and its own chimney, gave 88,798 cubic feet with a water-gauge at its inlet of 1·80 inches.

5th. The front or leading ventilator, with separate drift from upcast and its own chimney, gave 77,133 cubic feet with a water-gauge near its inlet of 2·10 inches.

6th. The two ventilators working simultaneously, having their inlets connected with the double drift from upcast, and each discharging by its own chimney, gave 90,310 cubic feet with a water-gauge of 2·10 inches at the inlet of the ventilator nearest to the upcast and of 2·15 inches near the leading ventilator.

There are some anomalous figures, when closely compared, attributable to the sliding shutters of the evasée chimney not being adjustable, to the difficulties of taking several anemometer observations by different observers underground, and also to the varying sectional areas and directions of the drifts connecting the ventilators with the upcast shaft, and with each other, but taking the first three experiments, it will be seen that the average of 80,812 cubic feet circulated by a single ventilator was increased to 108,479 by the duplex—about 35 per cent. increase.

The indicated horse-power of the engines was 179·65 in the duplex, and 70·20 average for each of the ventilators working alone, showing very nearly the theoretical proportion of the cubes of the volumes of air.

Comparing Nos. 4, 5, and 6 experiments, it is also seen that the single ventilator nearest to upcast alone, at 60 revolutions, gives nearly the same ventilation as the two working simultaneously; the leading ventilator at the same speed of 60 revolutions, probably owing to the increased frictional resistances, being inferior to the other. Had the drifts from the upcast been precisely similarly arranged in reference to each of the similar ventilators the volume of air would have divided itself equally between the two machines working simultaneously, and the horse-power developed by each engine would be theoretically one-half of that which

would be developed by one engine in the case of a single fan producing at the same speed a similar ventilation.

It appears to the writer a desirable arrangement in providing duplicate ventilators for a mine to erect them in such a manner with suitable connecting drifts so as to be able to use them either singly or as described in duplex or tandem fashion. In case of a breakdown, one is available for about 80 per cent. of the total quantity of air obtainable by the two ventilators, and would probably prevent the stoppage of the mine, while the capability of the two to give the larger range of ventilation without increasing the speed is of primary importance.

The subject is one well worthy of further investigation, and the writer hopes that having called attention to it some members may take it up.

The CHAIRMAN said he was sure the meeting would be glad to hear the observations of members on the subject. He had heard that the principle had been applied in a fan used for forcing purposes.

Professor MERIVALE said there was one point that occurred to him in connexion with Mr. Cochrane's paper, and that was as to connecting the first fan at the bottom of the evasée chimney. He thought the general custom was to make it at the top; but he did not think it made much difference; if at the top, better results were obtained from the first fan, and if at the bottom, better results were obtained from the second. He also wondered what the result would be if the fans were run both duplex and tandem by removing the division. He would like to ask Mr. Cochrane if he could put him in the way of obtaining any results of experiments, or any formulæ, by means of which to calculate the orifice of passage for various fans? It was an important point to be taken into account in designing a fan. He concluded that one would not be inclined to ventilate a pit by means of two fans arranged tandem if starting with a new plant. It would be better to put up a fan sufficiently large in the first instance. Of course, if additional ventilation was required ten or twenty years after a fan had been erected, it would be a good plan, but he took it that the experiments were the result of an idea of twenty-five years ago, when it was not generally known that to get the best effect from two fans they must be placed tandem.

Mr. T. H. M. STRATTON said that, according to the experiments, the fan nearest the upcast, and running at sixty revolutions, gave a water-gauge of 1·80 inches, and the leading fan 2·10 inches; but one had been taught to believe that a Guibal fan running at the same speed would always produce the same water-gauge, whatever the quanity of air. Had the fans separate orifices?

The CHAIRMAN said this was one of the anomalous points mentioned in the paper, and it was due to the fact that the shutters were not adjustable. They had to take the fans as they found them—by a proper adjustment of the shutters they could vary the water-gauge.

Mr. STRATTON said his point was that the efficiency of the fan was not at all dependent on the water-gauge. If a Guibal fan were revolved with its orifice directly communicating with the open air, would it not produce a water-gauge proportional to its peripheral velocity? Apart from its ability as a propeller of air would it not give a certain depression?

The CHAIRMAN said the question as to water-gauge and equivalent orifice was one which had never been properly appreciated. There had only been fact, and not theory, as regards the Guibal. Guibal's formula was not $V^2 + 2g$, but very different from it. It was a complicated formula, the area of the chimney and the size of the inlet entering into it. Replying to Prof. Merivale, he did not know of any formula of the kind referred to. M. Guibal had investigated the subject, but he did not know whether his researches would be published. They had not tried the combined experiments suggested by Prof. Merivale. It might be noticed that they recorded a ventilation at 1·10 inches, which must absolutely require 1·80 inches. So that they were very anomalous. The Professor had also asked why they made the connexion as they had done instead of bringing the spiral inlet to the other side. To do this would have involved a very expensive structure, and although better results might have been obtained, the expense and difficulty prevented it.

Professor MERIVALE—Then, you did practically do it in the ordinary way with the evasée chimney!

The CHAIRMAN—Yes; we continued the evasée chimney up to the inlet. Upon the other question, that it would be preferable to put a sufficiently large ventilator in the first instance, they never knew what might ultimately be the requirements of the colliery, and in putting in a sufficiently large ventilator they provided no duplicate. As mentioned in the paper, he thought it desirable to put in duplicate fans.

Mr. WALLAU said there were a great many arrangements possible with two fans, and it was a question as to which arrangement recommended itself most under certain circumstances. There were cases where two small fans upon one axle would give better results and be more economical to begin with than one large fan. The cases he meant were those where the water-gauge required could be readily obtained by a smaller fan, and two fans having each an inlet and being connected with the mine, of sufficiently large area, by running at a high speed would give the proper water-gauge, and the two small inlets would do as much work as the larger one. The smaller fans would be the more economical arrangement, for in arranging the ventilation in that way it was possible to have a much more simple drift than with the ordinary fan. For, if they put the fans on one axle, they could have bearings clear from the drift, and therefore free from the soot and dirt naturally present in a mine. This was a matter that had been considered of so much importance that Messrs. Black, Hawthorn & Co. had taken provisional protection for a certain arrangement of two fans. They were now making a model to thoroughly test it, and perhaps before long it would be brought under the notice of the Institute.

The CHAIRMAN—To get the same air from the mine, notwithstanding that smaller fans have to run at the same velocity of periphery as the larger one?

Mr. WALLAU—That is so.

Mr. THOS. BELL said before passing to the next paper he wished to propose a vote of thanks to the President for the very able paper he had laid before them. In doing this he would suggest that the discussion be adjourned until the paper was in the hands of the members.

The vote of thanks was unanimously adopted.

DISCUSSION ON MR. M. WALTON BROWN'S PAPER ON "EXPERIMENTS WITH EXPLOSIVES USED IN MINES," AND ON MESSRS. M. WALTON BROWN AND W. FOGGIN'S PAPER ON "EXPERIMENTS WITH CARBONITE."

Mr. M. WALTON BROWN said it appeared from the Report of the French Commission that an explosive whose detonation was due to an explosive wave may be harmless in the presence of fire-damp, if its temperature of detonation be below the temperature of the ignition of fire-damp. The normal temperature of ignition of fire-damp is about 1,200 degs. Fahr., but it was necessary that the effect of such a temperature should be prolonged for some time in order that the mixture might be ignited. The experiments of the French Commission showed that the retardation of ignition characteristic of fire-damp mixtures, the almost instantaneous mixture of the gases resulting from the explosive with the surrounding air, and the quick cooling consequent thereon, combine to make explosives whose temperature of detonation is less than 4,000 degs. Fahr. incapable of igniting explosive fire-damp mixtures under normal conditions of use; that is to say, in holes properly stemmed. The requirement was therefore, although not entirely sufficient, the discovery of an explosive whose temperature of detonation was less than 4,000 degs. Fahr. It naturally followed that the degree of safety became greater as the temperature of detonation fell below this value, and it might be assumed that the degree of safety was sufficient when the temperature of detonation of the explosive varied from 2,700 to 3,000 degs. Fahr. In the present stage of knowledge, which was specially derived from the conclusions of the French Commission, it appeared that dual mixtures were the most suitable. One of the substances was intended to diminish the temperature of detonation, and as regards the useful effect it was essential that this substance should be itself an explosive. Up to the present time the most suitable substance for this purpose was nitrate of ammonia, whose temperature of detonation was about 1,850 degs. Fahr. All high explosives, such as dynamite, gun-cotton, etc., possessed a very high temperature of detonation. This temperature was largely reduced by the mixture therewith of nitrate of ammonia, or other similar substances having a lower temperature of detonation, and the mixture formed a dual explosive which had an intermediate temperature. In

the use of an explosive the guarantees of safety diminished as the stemming diminished in length, or became otherwise imperfect. Without stemming, or when the explosive was detonated unconfined, the conditions of safety could not be formulated with exactness; in fact, one cartridge might be fired without ignition and another with ignition, haphazard, so to speak. The following table summarized the results of a series of experiments made at North Biddick Colliery, and

Explosive Employed.	Kind of Stemming.	Length of Stemming used, in Inches.												
		16	15	12	10	9	7	6	5	4	3	2	1½	1	½
Gunpowder..	Dry clay ...	...	I	...	...	I	...	...	...	...	...	...	...	...	...
†Tonite ...	Do. ...	2I	...	...	...	I	...	I	...	...	I	I	...	2I	...
Securite ...	Wet clay ...	N	...	N	N	...	...	...	...	...	...	...	...	...	...
Do. ...	Dry clay ...	I	...	...	...	...	I	...	I	I	I	I	I	2I	...
Do. ...	Coal-dust ...	N	...	...	...	...	...	I	...	...	...	...	...	...	...
Roburite ...	Dry clay ...	...	...	...	...	...	...	N	...	...	...	...	{	7I	...
													{	4N	
Ammonite ...	Wet clay ...	...	...	...	...	...	...	...	...	...	...	...	...	...	10N
Do. ...	Dry clay ...	...	...	...	...	N	...	N	...	...	...	N	{	15N	...
													{	2I	
Do. ...	Coal-dust ...	2N	...	N	...	...	...	...	...	N	...	N	...	2I	...

I Denotes ignition of gaseous mixture, and N non-ignition of gaseous mixture.

showed the effects produced by variations in the length of stemming. Four ounces of explosive were used in each experiment, and were fired into a mixture of 3 parts of coal-gas and 22 parts of atmospheric air, laden with coal-dust. No doubt a theoretical explosive should consist of one substance only, whose detonation should develop a sufficiently low temperature and only give uncombustible products. It was somewhat unfortunate that nitrate of ammonia, the only substance which was particularly valuable for use in dual mixtures, did not perfectly realize these conditions, and its facility of detonation was also somewhat unfortunate. In the formation of a dual explosive there was a certainty that the mixture, however carefully made, was never absolutely intimate. Consequently, if one of the mixed substances was combustible, or when detonated alone was susceptible of developing a temperature higher than 4,000 degs. Fahr., or if on detonation it yielded combustible gases, there was always a chance that a particle of that substance might exist on the surface of the cartridge, and might at the time of detonation ignite the surrounding explosive mixture. The irregularities in the ignition of unconfined explosives was due probably to this cause. These accidental ignitions naturally increased in proportion as the substance which might cause them was used in high proportions to form the dual mixture, as the mixture was less intimate and as the weight of the explosive increased. Practically, therefore, the essential for a safe explosive was the application of machinery, so as to ensure the utmost perfection in its mixture and to diminish to the lowest possible point, without reducing the aptitude of detona-

† Used without the protection of the Trench flame-extinguishing compound.

tion and power of the explosion, the proportion of the substance capable of igniting the gases. A further point in the use of explosives appeared to be the fact that the safety of their ignition in an explosive atmosphere depended upon the almost instantaneous mixture of the gases of the detonation with a sufficient volume of surrounding air. It was highly probable that it might be dangerous to fire a shot in a too limited space and with a weight of explosive too great for the volume of the surrounding air, as compared with the volume of the gases produced by the detonation. Continuing, he said that, in the experiments at Cwmaman and also at Washington Station, the volume of the tube in which the experiments were made as compared with the quantity of material used was about two to one. Possibly the certainty with which the ignition took place in each set of experiments was due to this. Since the issue of the report of the French Commission on Explosives the French Government had enacted that makers of explosives should mark upon the cartridges intended for sale the composition of their products in such a way as to allow of their temperature of detonation being calculated; and the government had given to the colliery owners the means of compelling the manufacturers to deliver to them (under penalty) only such materials as afforded the greatest guarantees of safety when used. The French Government had also felt it necessary to pass from the period of recommendation to that of enactment, and had now ordered the use of the new explosives, not only in fiery mines, but also in dusty mines, whose dusts were inflammable. For this purpose the Inspectors of Mines had forwarded to the government lists of fiery mines and dusty mines, whose dusts were inflammable, and had formally notified the owners of the class into which their mine had been distributed. Time would be allowed to colliery owners for choice of explosives suitable under the new law; but at all times they would be allowed to have, at their own risk, every latitude in the choice of explosives, the duty of the government being fulfilled when they had indicated, with all desirable precision, the technical conditions which the explosives must satisfy. The explosives recommended by the French Government were as follows:—1. Mixtures of dynamite, No. 1 (75 per cent. of nitro-glycerine and 25 per cent. of silica) and nitrate of ammonia, in which the proportion of dynamite did not exceed 40 per cent. for stone-work, and 20 per cent. for coal-getting. 2. Mixtures of blasting-gelatine (91·7 per cent. of nitro-glycerine and 8·3 per cent. of nononitric cotton) and nitrate of ammonia, in which the proportion of blasting-gelatine did not exceed 30 per cent. for stone-work, and 12 per cent. for coal-getting. 3. Mixtures of octonitric cotton with nitrate of ammonia, in which the percentage of gun-cotton did not exceed 20 per cent. for stone-work, and 9·5 per cent. for coal-getting. 4. Mixtures of dinitro-benzol and nitrate of ammonia, in which the proportion of dinitro-benzol did not exceed 10 per cent. for stone-work. The mixtures of octonitric cotton with nitrate of ammonia were manufactured by the State at the National Powder Mills, whilst the other mixtures were obtained from private manufacturers. The decree applicable to fiery mines and dusty

mines, whose dusts were inflammable, enacted that: 1. The use of blasting-powder was forbidden; 2. The worker was forbidden to use in the workings any explosives other than detonating explosives complying with the following conditions:—(*a*) The products of their detonation should not contain any combustible matter, as hydrogen, carbon monoxide, solid carbon: (*b*) Their temperature of detonation should not exceed 3,452 degs. Fahr. for explosives used in stone-work, nor 2,700 degs. Fahr. for those employed in coal-getting; 3. All explosives must be enclosed in cartridges, upon which should be shown the nature and proportions of the substances of which they were composed, so as to allow the temperature of detonation to be known, in accordance with the note attached to the decree; 4. The Inspectors of Mines should constantly assure themselves that the preceding conditions were complied with, by taking from the cartridges in use one or more samples for analysis; 5. The stemming of the explosives should be carefully made with plastic matter, so as to avoid blown-out shots; the length should not be less than 8 inches for the first 3 ounces of charge, with the addition of 2 inches for each extra 3 ounces, and should at all times exceed 20 inches; the cartridge should be fired by a detonator strong enough to ensure the detonation of the explosive even when unconfined; 6. The Inspector of Mines may authorize the use of other explosives in stone-drifts, or variations in the amount of stemming to be used.

Mr. J. A. G. Ross said the question of the temperature of detonation was partly discussed at the last meeting as being quite independent of the flame, the flame being to a certain extent an accident. Captain Noble, in his experiments before the Institution of Civil Engineers, demonstrated by calculation and experiment that the temperature of the detonation of English gunpowder was about 4,000 degs. Fahr., and he also went on to state that at some considerable distance from the seat of the detonation, and consequently some short time afterwards—some fractional portion of time,—that temperature was continued to the muzzle of the gun, where he estimated it to be about 400 degs. less. But that temperature which was left without any flame would be quite sufficient to ignite fire-damp. Captain Noble also mentioned with regard to gun-cotton and such-like explosives that the probable temperature was double that of gunpowder. So that, according to these experiments, the more violent the detonation—flame or no flame—the greater the danger of explosion. He (Mr. Ross) gathered that the deductions would be the same in these experiments, which, he presumed, would give the same results in a shot-hole as in a cannon.

Mr. ORSMAN (Wigan) said the publication of the translation of the French Commission's report gave valuable information as to the temperatures at which certain explosives detonated. There were three classes of explosives. First, gunpowder—simply a question of burning and not of detonation; second, detonation pure and simple, such as nitro-glycerine; third, a mixture of the two, such as carbonite and ardeer powder, brought out by the Nobel Company. With gunpowder an enormous temperature was produced; with nitro-glycerine also; but with explosives such as those composed of dinitro-benzene and nitrate of ammonia the temperature of

detonation was much less. With carbonite and other explosives containing an excess of carbon large quantities of the invisible odourless, but highly poisonous, gas carbon monoxide were formed. In future the fumes given off by such explosives would be an important matter, and the presence of carbon monoxide would not be tolerated in a mine either by the miner or by the scientific manager who might have to deal with them, and therefore they must come sooner or later to the dual mixtures of nitrate of ammonia with organic compounds. The French Commission had advocated these dual mixtures, and he would also draw the attention of the members to the report of Her Majesty's Inspectors of Explosives for the year 1890 on the subject, in which, although the mixture of nitrate of ammonia with nitrated hydro-carbons was acknowledged to be safe, yet it would not be permissible to mix nitrate of ammonia with nitro-cotton, nitro-glycerine, or any of the explosives containing nitro-glycerine, such as dynamite, gelignite, etc., on account of the liability of the nitrate of ammonia to decompose, free acid being formed which would quickly decompose the organic nitro-derivative. He might conclude by saying that the safest explosives they had at the present time were—and those of the future would be—those which combined nitrate of ammonia with nitrated organic substances, as they found in roburite or ammonite.

Mr. BONSER said that the new safety explosive, ardeer powder, was introduced by Messrs. Nobel's Explosives Company, Limited, almost simultaneously with grisoutite (and was nearly identical in character), which had received such favourable notice from M. Macquet before the Belgian School of Mines, who had reported to the French Commission. In the case of ardeer powder the temperature was reduced by the introduction of 50 per cent. of sulphate of magnesia (the ordinary Epsom salts of commerce). The speaker then named the constituent parts of these explosives, and went on to say that 2,000 degs. centigrade might be put down as the temperature at which fire-damp would ignite. No doubt if some scientist could determine the actual temperature of an explosion that of ardeer powder would be found to be about 1,100 degrees centigrade. The tests to which it had been subjected to by blowing out shots of 1 lb. weight into explosive mixtures of gas and air and dust proved its perfect safety most conclusively. It was also the cheapest explosive now offered.

The CHAIRMAN said he thought they might congratulate themselves on having present the representatives of the most important firms who manufactured explosives. Whatever might be the result they knew that the talent of the highest chemists was being brought to bear on the question, and it was to be hoped that in time one or other of the "ites" would be proved safe. He had pleasure in moving a vote of thanks to Messrs. Brown and Foggin for their valuable papers, the discussion on which would be continued from time to time.

The vote of thanks was cordially adopted.

ELECTION OF OFFICERS.

The Scrutineers reported the result of the ballot as follows:—

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The CHAIRMAN congratulated the members on having elected as their President for the ensuing year a gentleman so well known to them all, and who had worked so assiduously for the Institute, certainly from the time he (Mr. Cochrane) had known it, and whose zeal in the interests of the Institute would carry it on to greater successes than it had hitherto reached. It needed just now a strong President and a strong Council, for it must take the lead as it had always done. It only remained for him now to thank them for the manner in which they had tolerated him during his presidency. He was unfortunately compelled to be away for the early part of it, but his Council had done quite as well as ever he could have done, and in resigning the chair to Mr. Simpson he could only express the pleasure he had had in holding that responsible position, which would be enhanced if he knew that he had done his work in a manner which met with their approval. He was sorry Mr. Simpson had been obliged to leave early and that he could not therefore hand over the chair to him, but must for a while leave it vacant. He would also congratulate them on the appointment of the new Council, who would, he felt sure, proceed to their work with all the energy of which they knew them to be capable.

Mr. THOS. BELL (H.M. Inspector of Mines) asked to be allowed to express on behalf of the members their thanks to Mr. Cochrane, and their appreciation of his very valuable services and the manner in which he had carried out the duties of President during the year. They were all sorry to lose Mr. Cochrane as President of the Institute, but his year of office would not be forgotten by the members, and they hoped he would always lend his presence at the meetings to support his successors.

The meeting then terminated.

SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

GENERAL MEETING, AUGUST 6TH, 1891.

MR. JOHN WILLIAMSON, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting and of Council meetings were read, confirmed, and signed.

A letter was read from Mr. W. F. Howard, the Secretary of the Chesterfield and Midland Counties Institution of Mining Engineers, conveying an invitation from Mr. J. A. Longden to visit the Alfreton, Teversal, and Pleasley Collieries.

The SECRETARY said that members of this Institute might discuss any paper in the Transactions of the Federated Institution. If in reading the Transactions they thought it would be instructive, or if they wished to get further information upon any of the papers they saw there, they could bring it forward at any of the meetings of the Institute, and have it discussed, and they could get answers by means of correspondence from the authors of the papers.

The PRESIDENT then read the following paper on the "Barometer and Thermometer, as applied to Mining," which was intended to supplement the paper read by Mr. Fairley on "Colliery Explosions" at the meeting on April 2nd, 1891:—

BAROMETER AND THERMOMETER AS APPLIED TO MINING.

By John Williamson.

Mr. Fairley in his paper gives the opinions of the Inspectors of Mines on the vicissitudes of the weather. In the closing remarks of his paper he says:—"In no case do the reports give any encouragement to the theory of a connexion between the vicissitudes of the weather and the occurrence of explosions of fire-damp; when an opinion is given by the Inspectors it is generally against this theory. As a barometer, a body of fire-damp is more sensitive than anything else, and any warning that a ventilating engineer may receive from meteorologists outside cannot be of practical use as regards danger from gas."

When it is said that the reports of the Inspectors give no encouragement to the theory of a connexion between the vicissitudes of the weather and the occurrence of explosions of fire-damp, have we to understand that in the opinion of the Inspectors the changes of the weather causing a falling barometer have never been the means of producing large bodies of gas and explosion?

It seems when they give an opinion it is generally against this theory. The writer thinks it is understood that the vicissitudes of the weather causing a low barometer will not produce an explosion in a well-ventilated mine, and where proper precaution is taken; but it is possible for an explosion to take place with a falling barometer in mines containing bodies of fire-damp, and where there is defective ventilation, and a want of proper precaution, the opening of doors or the derangement of brattice or air pipes in some mines is sufficient to cause an accumulation of gas, even with a high barometer, and produce explosions.

Then, "as a barometer, a body of fire-damp is more sensitive than anything else, and any warning that a ventilating engineer may receive from meteorologists outside cannot be of practical use as regards danger from gas." As to a body of fire-damp, it would not be a prudent thing for managers to permit a body of gas to exist for the purpose of being used as a sensitive barometer.

It is a well-known fact that the rising and falling of the barometer invariably causes bodies of gas to increase and diminish in bulk.

The late Sir Warington Smyth in his treatise on "Coal and Coal-Mining" (page 204), says:—"The evolution of gases from the coal is greatly affected by the pressure of the atmosphere, a notably larger amount being emitted when the barometer is low; and hence that instrument becomes a useful adjunct in judging of the amount of the ventilation needed at different times."

It may be said that the opinion of the Inspectors is, that if the mines are properly ventilated, and proper precautions are taken, the changes of the weathe are not in themselves sufficient to produce an explosion. Then, as to warning from meteorologists: a prudent manager would not consider it necessary to wait f

warnings from meteorologists if the movement of the barometer at the mine had proper attention. The conditions of mines vary, and are only known by the manager, not by the meteorologist. If a meteorologist can predict so far as to say, we may expect changeable and disturbed weather, and there is every probability of a falling barometer, the writer does not think this at all objectionable. It may be looked at in another light. The writer thinks it may confirm the opinion the manager has formed from his knowledge of the movements of his own barometer. It is not from the point at which the mercury may stand that a judgment of the state of the weather may be formed, but also from its rising and falling, and from the movements of immediately preceding days as well as hours, keeping in mind effects of change of direction, and dryness or moisture, as well as alteration of force of wind.

In general, wind affects the barometer more than rain, and temperature is influenced by wind. Just before great changes the barometer in the mine rises, whilst the barometer at the surface falls, with considerable fall of temperature at the surface only.

In the writer's opinion it is not sufficient to simply have a barometer at the surface. For the proper guidance of a colliery manager it is necessary to have a barometer in the furthermost part of the underground workings; readings to be taken by competent men frequently, and properly recorded. Competent men who carefully watch the movements of the barometer are always prepared to caution the workmen and inform them when great changes are approaching.

The best mode of dealing with abnormal conditions of the atmosphere undoubtedly is to prevent, as far as possible, accumulations of gas and an explosion by efficient ventilation, and to make use of some of the preventives, such as not to allow accumulations of inflammable gas in any part of the mine; only to allow blasting when the workings are free from gas, and where there are no indications of gas on the flame; to strictly prohibit blasting fast, and only to permit blasting to be done by order of properly qualified men. Blasting ought to be under the control of the most practical and trustworthy men.

There are few colliery managers who do not believe that a falling barometer is calculated to produce more gas than when the barometer is high, and it is well understood that colliery explosions have taken place with both low and high barometers. The explosions with a high barometer might probably be due to accumulations of gas produced by a low barometer and left lurking in some unventilated place.

The barometers and thermometers fixed at mines are to be frequently observed and their movements recorded. A prudent manager will not wait for the barometer to fall to a low point nor a report from some meteorologist before he acquaints his officials of the fact, but will, as soon as he finds the barometer move, take such steps as are necessary for the safety of the mine. There are certain natural laws, such as chemical changes caused by more or less heat, electrical

action, or mere gravitation, which govern the movements of both the barometer and thermometer, and, as a rule, these laws are certain in their action. If all the movements of the barometer and thermometer and the points of the wind, etc., are properly recorded and a proper chart kept, such information ought to be of great service to a colliery manager.

It has been found, when the wind was from the south or south-west and the barometer low that furnace ventilation was more difficult than when the wind was from any other point. The furnaceman could tell you when the barometer was low, as it caused him more work to keep up the regular quantity of air.

As to the value of the barometer and thermometer in connexion with mining, we may refer to the Mines Regulation Act, where it says, "A barometer and thermometer shall be placed above-ground in a conspicuous position near the entrance to the mine." This was embodied in the Mines Regulation Act from suggestions made by eminent practical mining engineers. The late Mr. J. T. Woodhouse was always particular in ordering the use of barometers and thermometers at all the mines he had to do with, and he was most particular in seeing that the furnacemen were supplied with these instruments, and to show how much Mr. Woodhouse appreciated these instruments he would insist upon having the very best, and he would have them graduated in such a manner as to show the furnaceman when to "fire up," etc.

It is a fact that when bodies of gas have been present in goaves, and resting just above the roof of the mine, the gas has settled down when the barometer was falling, and filled the miner's lamp (hanging on a prop) with flame, the miner being quite unconscious of what was going on until he either heard the cracking noise or smelt the burning gas. This was a frequent occurrence.

We have in the Report of the Accidents in Mines Commission the minutes of evidence of Mr. Wales, Mr. Hall, and others, giving their experience of the uses of the barometer in mines:—

"Mr. Wales—3,095—Believes that gas exudes in larger quantities with a low barometer. 3,096—We find in most collieries a much larger cap with a low barometer than with a high barometer. 3,097—I have observed this frequently.

"Mr. Hall—3,557—Gas comes off much more freely with a low barometer. 3,558—Gas comes off at goaves with a low barometer. 3,559—I have frequently tested stoppings connected with old goaves, and gone to the pipe when the glass has been high and when the glass has been low, and sometimes the pressure was in-over when the glass was high, but always when low the gas has been coming out very freely. 3,561—I think frequent observations of the barometer are an advantage. 3,565—I am satisfied that with a low barometer very much more gas comes into the air-ways. 3,648—Gas comes off in larger quantities with a low barometer, but still accidents occur with a high barometer. They have occurred.

"Mr. Bagot—4,365-6—My experience of barometers and blowers, and particularly barometers in explosions is, that it is after the barometer has fallen and begun to rise again that they occur. 4,367—When the barometer is low, gas is more liable to blow. 4,417—If you rely upon the barometer and neglect ventilation it would be a most serious question.

"Mr. Galloway—13,672—Does not think the indications of the barometer too sluggish for mines. 13,677—You are still inclined to infer that there is sufficient connexion observed between the phenomena underground and the changes of the weather to make it important that the manager should keep a strict eye upon the indications that are presented to him in that way? I do."

Some years ago experiments were made by the writer with the barometer, thermometer, and hygrometer in mines, and frequently it was found that a body of gas thickened with a falling barometer and a slightly increased temperature; the variation of the barometer in the mine is much more than that of the thermometer. The temperature of many mines in the workings does not vary during the year more than about two degrees.

The hygrometer shows the moisture of the air up to a certain point, and is not considered of much importance in connexion with mining on account of the uncertainty of its action. For the air of mines is, as a rule, more or less charged with moisture.

At a colliery in the county of Durham, where there was much water, the beam of the pumping engine broke and the mine was drowned up for some time; there was only one shaft, which was divided by brattice to form an upcast and a downcast shaft; the water rose in the shaft for 35 yards above the inset. In one of the districts where there were workings on the top of a large fault much gas was made. During the stoppage of the pumps, and when the water was 35 yards up the shaft there were several water or gas blasts, blowing the water to the top of the shaft. This always took place when the barometer got very low, and was due to pent-up gas; all fire lamps, and open lights were, therefore, removed from about the top of the shaft. Many other similar cases could be given.

Within a short distance of this colliery a water-level was driven partly in sand, gravel, and clay; after driving about 200 yards there was great difficulty in ventilating the tunnel, and the exuding black-damp or carbonic acid gas was very great when the barometer was low, often causing a suspension of the work. The tunnel was of an egg-shape, and 4 feet 6 inches high; the air boxes were 15 inches by 8 inches laid on the bottom of the arch, and connected with a small furnace at the entrance of the tunnel; the tram rails being laid on them (the boxes). The sudden filling of the tunnel with carbonic acid gas as the work advanced was remarkable, sometimes the workmen were in a state of asphyxia before they could get out, and as soon as the barometer began to rise, and the wind got to the north or north-west the carbonic acid gas disappeared in as little time as it came, and when

the flame of the candle was applied to any of the crevices in the gravel, where the carbonic acid had came out, it was pulled or sucked in.

In North Staffordshire, from the bottom of a shaft 300 yards in depth, a rock-head or crut was driven for the purpose of recovering several seams of coal which lay at an angle of 45 degs. to 50 degs.

In the driving of the crut the coal seams were intersected, and one of the seams made a large quantity of gas, into which a head was driven for about 5 yards; at 3 feet within this headway a 14-inch brick stopping was put in with an 1½-inch pipe inserted. The stopping was hermetically sealed. The pipe was carried to the shaft bottom and fixed, with the end turned up the shaft, when the gas coming from the headway was ignited, and gave a flame about 2 feet long which lighted up the shaft bottom.

Sometimes the closing of the separation doors, or a sudden drop of the cage in the shaft bottom would extinguish the light, and at other times the flame was with difficulty blown out. The writer gave some attention to this, and found the extinction of the light was due to changes of the barometer. When the barometer was high there was much less light, and it was more easily extinguished than when the barometer was low, with a much larger flame.

It is well known that the barometer shows the weight or tension of air, the thermometer heat and cold, or temperature, and the wet thermometer compared with a dry one, the degree of moisture or dampness. If any good has to result from the use of these instruments in connexion with mining there must be a more elaborate and methodical dealing with them. We appear to know very little about their proper value. What appears to be known is that a falling barometer produces more gas, and increases bodies of gas, and in some mines (especially old mines) it produces black-damp or stythe.

Within recent years the proper use of the barometer and thermometer is better understood on the surface. Where is the captain of a ship who would think of going to sea without these instruments? By the use of a good reliable barometer a ship captain can invariably foretell the coming weather. It is clear that the uses of these instruments are better understood on the surface than in the mine; then, if the barometer and thermometer are of so much value at the surface, there is nothing in the writer's opinion to prevent them from being equally so for the mine, if they could have the same amount of attention given in the mine as at the surface.

Mr. W. B. SCOTT said that to properly connect the President's paper and Mr. Fairley's paper it would be necessary to add to the latter a statement of the positions of the barometer at the time of the explosions, because on the one hand they had a statement of explosions in different districts, and on the other hand they had the President's statement of opinion that the barometer had something to do

with them, and so it would be necessary, to make the papers of greater value and connect them carefully, to have a statement as to the condition of the barometer at the time of the explosions. He took it that if gas existed in the coal at so high a pressure as 400 pounds to the square inch, how could they consider that a slight movement of the barometer had anything to do with the escape of gas? After all their study of the laws which governed the exudation of gas they had reached a very short distance yet. If Mr. Fairley was in a position to give the condition of the barometer at the time of the explosions to which he had referred in his paper it would prove of great value. It must be a common experience with everyone that, given a high barometer and a north wind, gas would disappear and there would be an indraught. Why was that?

Mr. A. SOPWITH said that so far as his own experience of this went, that he was bound to admit that he knew rather less now than he did when he began, but he thought it would be found that the mere question of what the height of the barometer was when the explosion took place was of comparatively very slight value, because it was really more a question of the relative positions of the barometer in relation to, probably, three or four weeks' previous atmospheric conditions.

Mr. W. H. GLENNIE thought that, undoubtedly, this was a question that divided itself into two or three parts. In the first place, for an explosion to occur there must have been a body of gas present at the time, and that body of gas might have arisen from neglect in the colliery, or from many other causes. Therefore, the mere knowledge of the height of the barometer at the time of the explosion would be certainly misleading, as there were a number of other things to be taken into consideration. Another interesting point was the connexion between the movements of the barometer and the gas as found in mines, and that was a very intricate and important question. He once carried out some experiments on this point, extending over a period of about nine months. He had a place in a colliery where there was a constant blow-off from a fault in a part which had been worked some years before and then closed up. He kept a small gas-way from this "feeder" into the main air-way to carry the gas off, a small supply of air being carried into it at the same time. Just at the mouth of this gas-way he had a record taken twice a day of the height of the "cap," measured by attaching a scale to the side of the lamp. However, it failed in two or three ways. The ventilation was somewhat irregular, causing the amount of air which became mixed with the gas to be also irregular, and the trial did not produce any regular log. There happened to be one or two very violent storms and rapid variations of the barometer during the course of the experiments, and he was able to get indications of these from the increase of the gas some eight or ten hours before the barometer moved on the surface. The results of the experiments so far as they were carried out, proved that the gas in a mine was more sensitive than a barometer on the surface, to the extent of some hours. He thought to that extent he succeeded, but it would be very interesting if someone who had

a place in a colliery where they could apply more accurate means of observation, would carry out similar experiments.

Mr. FAIRLEY said that his remarks applied more particularly to shallow mines and badly ventilated mines, than to deep mines, or to mines that were well ventilated. In the summary of the final Report of the Royal Commission on Accidents in Mines the Commissioners refer to this question as follows:—

"In forming an opinion as to the importance of this question we must draw a broad line of distinction between those collieries in which an active ventilation is constantly maintained by powerful agents, and those in which natural ventilation is trusted to, or where only a feeble current is artificially conducted through the workings. It needs no argument to show that, under these latter circumstances, the condition of the air of the mine must be seriously affected by atmospheric changes, and that the barometric, thermometric, and hygrometric phenomena must be taken into account in estimating the present and impending state of the air in the mine workings. It has been suggested that warnings of approaching changes in atmospheric conditions might be issued by the Meteorological Office to colliery districts in the same manner as they are communicated to the seaports; and a recent memorial from a body representing a large number of the coal miners was addressed to the Secretary of State, to propose the establishment of meteorological observatories with this object in view. We do not think that any benefit would arise from the establishment of additional observatories, and except that, in reference to what has been stated above, it would be advantageous to a manager of a colliery to know that a barometric depression was approaching, we do not understand on what principles, in the present state of our knowledge, warnings worthy of any confidence could be issued. We consider, moreover, that the official dissemination of warnings might lead to an exaggerated estimate of their value, and might consequently be liable to withdraw attention from the absolute necessity for constant watchfulness in taking all precautions essential for guarding against the accumulation of fire-damp in any part of a mine. The closely allied question of the connexion of actual colliery explosions with atmospheric changes has received our careful attention. Some remarkable instances have appeared to support the view that explosions accompany unusual depressions or specially rapid falls in the barometer, but the evidence which has been adduced to show that this view is of general application seems to us most imperfect and untrustworthy. Indeed, the absence of a general connexion between colliery disasters and barometric changes is practically established by the tables compiled by some of your Majesty's Inspectors of Mines, by the Northern Institute of Engineers, and recently by Mr. Thomas Embleton in communications made to the Midland Institute."

Upon the proposition of Mr. W. B. SCOTT, seconded by Mr. JOHN HUGHES, a vote of thanks was accorded to the President and to Mr. Fairley for their papers.

CHESTERFIELD AND MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

ANNUAL GENERAL MEETING,

HELD IN UNIVERSITY COLLEGE, NOTTINGHAM, ON SATURDAY, JUNE 27TH, 1891.

MR. JOHN JACKSON, J.P., PRESIDENT, IN THE CHAIR.

The CHAIRMAN (Mr. John Jackson, the retiring President) remarked that they had arrived at the end of the twentieth year of their existence, and the second, or nearly that, in which they had been connected with the Federated Institution of Mining Engineers. They might congratulate themselves, he thought, that they were still a compact body, and that they contributed matters of mining interest to the Institution. It would be seen from the report that they were not so numerous as they were three years ago; but still they fairly held their own, taking into consideration the fact that many of their members were also members of other institutions which were affiliated to the Federation, who preferred to retire from the auxiliary institutions and restrict their membership to one. There was one question which would come before them during the next year, viz., the desirability or otherwise of holding so many meetings in the year. Now, they had three meetings of the Federated Institution and four of their own Institution. The proposal to be made was that they should blend some of these meetings so as to make the attendance less arduous to members. He thought there was another matter in the report they could congratulate themselves on, and that was their financial position. Either by good judgment or good luck their investment was now £100 more value than when they made it some years ago. Death had been busy during the last few months, and their Institution had not escaped its ravages. It had taken both the high and the low, and they had to record the loss of a very old and valued friend in Lord Edward Cavendish, who was their first President. They could only express and deplore the loss they had sustained, and he was sure they would all endorse the action of the Council in passing their vote of condolence with the members of Lord Edward's family. He begged to move the adoption of the report.

Mr. J. B. SMITH (Newstead Colliery) seconded the motion, which was carried *nem. con.*

REPORT OF THE COUNCIL.

The following is the usual comparative summary of numbers and finance in the past three years, viz.:—

	1888-89.	1889-90.	1890-91.
Honorary Members ...	15	15	15
Life Members	8	8	8
Members	193	187	191
Subscribing Members ...	6	7	7
Associate Members ...	25	26	19
Students	11	10	11
	258	253	251

	£ s. d.	£ s. d.	£ s. d.
Cash Receipts	367 11 3	342 4 0	379 4 6
Cash Payments ...	373 12 5	330 1 3	396 11 1
Bank Balance	34 6 1	46 8 10	29 2 3
Invested Fund... ...	430 0 0	430 0 0	533 6 8
	£464 6 1	£476 8 10	£562 8 11

Arrears considered recoverable at end of	1888-89.	1889-90.	1890-91.
	£91 3 6	£89 3 6	£52 8 0

Twenty-two new members (including 3 Students transferred), 2 Honorary Members (including 1 transferred from Members' list), 2 Associate Members, and 4 Students have been elected during the year—total 30 (as against 16 last year).

The total retirements from all causes are 32 (as against 21 last year), viz.:—18 Members (1 of whom is now an Honorary Member), 2 Honorary Members, 9 Associate Members, and 3 Students (now Members).

There has been a net increase of 4 Members and 1 Student, and a net decrease of 7 Associate Members.

Two deaths during the year have been recorded.

The total number on the roll of the Institution as for the year commenced 26th March last, was 251.

The income of the past year was £37 0s. 6d. more than that of the previous year, compared with which a satisfactory increase appears on nearly every item, but particularly from the increased number of new members. Several members of long standing in this Institute, and hitherto members also of one or more of the other Federated Institutes, have discontinued to pay more than one subscription, selecting the Institute with which they are most directly connected as the recipient, and themselves obtaining for a single subscription greater advantages than for the several subscriptions previously.

The slight falling off in total numbers—2 only—is owing chiefly to this cause, but also to a more rigid exclusion of persons unduly in arrear. This has involved a curtailment of the arrear list carried forward.

The expenditure has been £66 9s. 10d. more than that of the previous year, and £17 6s. 7d. more than the year's income. Compared with the previous year, there has, however, been a general reduction upon nearly every item except for printing and stationery, the excess on which amounts to £87 19s. 11d., including under that head the calls paid to the Federated Institution.

Taking into consideration the altered state of things through the Federation, the Finance Committee arranged with the Secretary in the concluding quarter of the past year a reduction of £40 per annum in respect of his salary and services; and with this saving the Council think it will be unnecessary at present, at least, to raise the rates of subscription.

The working of the Federation during the earlier part of the past year was in some respects unsatisfactory; but the work is now well in hand and the Transactions will be regularly issued. A glance at the number and subjects of papers published since the Council's last report is sufficient to convince anyone interested in mining matters that a volume has been added to each member's library far beyond the value of his subscription.

The meeting of the Federated Institution for the first time held in the district of this Institution at Nottingham, on 24th and 25th September, 1890, under the vice-presidency of Mr. Jackson, was altogether successful. The other Federation meetings during the year have been at Edinburgh on 24th and 25th July, 1890; at Newcastle-upon-Tyne on 21st and 22nd January, 1891; and in London on 28th and 29th May, 1891.

The local meetings have been at Chesterfield on 12th July, 1890, at Derby, 10th January; and at Sheffield, 11th April last. A Joint Meeting with the Midland Institute was also held at Sheffield on 11th April, when members of both Institutes were well represented.

The complete list of papers actually published in the Transactions of the Federated Institution of Mining Engineers since the Council's last report is as follows:—

North of England Institute.—"The Hauraki Mining District (Northern Section), Auckland, New Zealand." By D. H. Bayldon.

"Ramsay's Patent Improved Levelling Staff for use in Mines." By W. Ramsay.

"On the Value of Photography to Mining Engineers." By A. L. Steavenson.

"Experiments with Explosives used in Mines." By M. Walton Brown.

Midland Institute.—"The action of Tidal Streams on Metals." By Thomas Andrews.

"The Stauss System of Colliery Cage Props." By E. B. Clarke.

"On the Difference between the Seams in the Northern and Southern parts of the Yorkshire Coal-field, as shown in some of the deeper Sinkings." By John Nevin.

Presidential Address. By Mr. Joseph Mitchell.

"On the Coal-field adjoining Barnsley." By Robert Miller.

"On the Parker and Weston Pump for Colliery purposes." By G. B. Walker.

South Staffordshire Institute.—Presidential Address. By Mr. Henry Lea.

"Notes on Safety-Lamps." By H. W. Hughes.

Chesterfield Institution.—"Soars' Patent Coal-Lowering Apparatus." By Charles Soar.

Presidential Address. By Mr. John Jackson.

Memoir of Joseph Timms.

"Comparative Experiments on a Capell and Schiele Fan, working under similar conditions." By Maurice Deacon.

Federated Institution.—(North of England Institute): "The Economical Working of Steam Boilers at Collieries." By W. Armstrong, Jun., and W. J. Bird.

(Chesterfield Institution): "A Geological Sketch of the Town and District of Nottingham." By George Lewis.

"A Few Notes on the Ironstone Deposits of Leicestershire." By M. H. Mills.

"An Experience with Explosives used Underground." By Hargrave Walters.

"Elsom's Improved Method of Lighting Miners' Safety-Lamps while Locked." By John Taylor.

"The S. C. P. Miners' Electric Safety-Lamp." By G. E. Smith.

The Invested Fund of the Institution, originally £400 of 4 per cent. Debenture Stock of the Midland Railway Company, purchased in 1879 for £430, has recently been converted by the Company under Parliamentary Powers (Midland Railway Act, 1889, 52 and 53 Vict., ch. XXXIX.) into equivalent 3 per cent. Debenture Stock £533 6s. 8d. by the Company's Certificate, thus producing at 3 per cent. the same annual interest as £400 at 4 per cent. As the 3 per cent. Stock is now at par, it is clear that the present market value of the investment is £100 greater than the sum for which it was purchased.

The death of Lord Edward Cavendish, occurring on the 18th May in the current year, has withdrawn from the Institution its first President, who held office by annual re-election for eighteen consecutive years until obliged to retire by the pressure of other duties. The Council, on behalf of the members of the Institution, have addressed to Lady Edward Cavendish and the Duke of Devonshire resolutions which have been acknowledged, expressing their earnest sympathy and condolence, together with the assurance of their high appreciation of the valuable assistance Lord Edward rendered to the Institution, as Patron, President, and Member, and how much they deplore the loss they with the country have sustained in his premature decease.

The annual meeting of the Institution, as already announced more particularly, will be held at Nottingham on the 27th June, 1891, when a resolution recommended by the Council for adoption by the meeting, will be moved to the effect "That this Institution continue its connexion with the Federated Institution of Mining Engineers for another year."

The President, Mr. Jackson, whose services during the year, and particularly in connexion with the Federation meeting in Nottingham, the members cannot but warmly feel and acknowledge, upon vacating the chair at the close of his term of office will introduce the President-elect, Mr. Longden, who will deliver an address.

The next Federation Meeting is fixed to take place in the district of the South Staffordshire Institute, at Birmingham, on 22nd and 23rd September next; and a one-day excursion meeting of the Chesterfield Institution is arranged, at Mr. Longden's suggestion, to be held in the locality of Alfreton, on 21st October.

APPENDIX.

Donations to the Library and Museum.

British Association for the Advancement of Science. Report of Meeting at Leeds, 1890. From the Association.

Mineral Statistics of the United Kingdom, 1889. From Mr. A. H. Stokes, H.M. Inspector of Mines.

Mines. Blue Books, etc., presented by Mr. A. H. Stokes, viz.:—

1885. Newbottle Colliery Accident, Report on.
1886. Mardy Colliery Explosion, Report on.
„ Tenth Annual Report of H.M. Inspectors of Explosives.
1889. H.M. Inspector's Report for the Midland District.
„ List of Mines Worked in the Year 1889.
1890. Mossfields Colliery Explosion, Report on.
„ Summaries of Statistics of Government Inspectors' Reports.
„ Coal Mines (Explosions) Returns.
„ Mr. H. Hall's Report of Experiments with Coal Dust.
„ Minutes of Home Secretary, *re* Coal Dust.
„ Fourteenth Annual Report of H.M. Inspectors of Explosives.

Manchester Museum, Owen's College. Report, year ending 30th September, 1890.

National Boiler Insurance Company. Chief Engineer's Report, 1889. From the Company.

Potts' Mining Register and Directory, 1890. From Mr. W. J. Potts.

Spon's Engineer's and Contractor's Diary and Reference Book for 1891. From Messrs. E. and F. N. Spon.

Shaw's System of Signals and Tests of Dangerous Gases in Mines. From Mr. W. S. Gresley.

The Thomson-Houston Electric Motor. From Mr. W. S. Gresley.

The Universal Mining Code. By J. Stevens and R. S. Corbett. From the Authors.

Wire, its Manufacture and Uses, a Treatise on. By J. Bucknall Smith, C.E. From "Engineering."

Chesterfield and North Derbyshire Almanack for 1891. By Mr. T. P. Wood. From the Author.

Year Book of Scientific Societies, 1891. Purchased.

New South Wales: Its History and Resources, 1891. From the Agent-General for New South Wales.

New Zealand.—Papers read at the Mining Conference held at Dunedin, March, 1890, by G. J. Binns, Hon. Sec. From the Author.

New Zealand.—Reports on the Control and Inspection of Mines, 1880, 1881, 1883. From Mr. A. H. Stokes.

New Zealand.—Accidents in Mines, Reports, 1887.

Smithsonian Institution Reports, and National (U.S.A.) Museum Reports, 1886, 1887, 1888. From the Institution.

"The Colliery Manager" (Monthly). From the Editor.

"Machinery Market" (Monthly). From the Editor.

"The Colliery Engineer," Pennsylvania (Monthly). From the Editor.

EXCHANGES.

Civil Engineers, Minutes of the Institution of. From the Institution.

Cleveland Institution of Engineers, Proceedings of the. From the Institution.

Liverpool Engineering Society, Proceedings of the. From the Society.

Manchester Geological Society, Transactions of the. From the Society.

Mechanical Engineers, Proceedings of the Institution of. From the Institution.

North of England Institute of Mining and Mechanical Engineers, Transactions of the. From the Institute.

Scotland, Mining Institute of, Transactions of the. From the Institute.

South Wales Institute of Engineers, Proceedings of the. From the Institute.

United States Geological Survey, Eighth Annual Report, 1886-7, and Ninth Annual Report, 1887-8. From the Survey Department.

Pennsylvania (U.S.A.), Second Geological Survey of. From the Survey Department.

	Income.	£	s.	d.	£	s.	d.
151	Members	237	16	6			
	One formerly Student paid Entrance...	0	10	6			
	One Member of January, 1890, paid Entrance	1	1	0			
7	Subscribing Members	7	7	0			
24	Associate Members and Students ...	24	0	0			
	Two paid extra as Members and Entrance	2	4	0			
	One paid Arrear, not in List	1	0	0			
14	New Members and Entrances	36	15	0			
4	New Associate Members and Students	4	0	0			
200					314	14	0
	Two Members paid in advance ...	3	3	0			
	Five New Members paid in advance and Entrances	13	2	6			
	One Associate and Two New Students paid in advance	3	0	0			
					19	5	6
	Arrear Subscriptions received in 1888-9	2	11	6			
	Do. do. 1889-90	23	1	0	25	12	6
					359	12	0
	Excerpts sold				0	9	0
	Midland Railway Debenture Interest...				15	12	0
	Bank Interest				2	11	6
	Letting of Council Room				1	0	0
	Total Receipts ...				379	4	6
	Unpaid Arrears, per Subscription a/c...	58	5	0			
	Do. 1889-90 Account ... 35 18 6						
	Do. 1888-9 do. ... 22 18 0						
	Do. 1887-8 do. ... 4 14 6	63	11	0			
		121	16	0			
	Irrecoverable	69	8	0			
	Net arrears to collect				52	8	0
	Balance from last year				46	8	10
					£478	1	4

Expenditure.	£	s.	d.	£	s.	d.
Federated Institution of Mining Engineers for copies of Proceedings, supplied at 15s. per Member:—						
Balance on First Call of 15s. per Member...	103	10	0			
First Instalment on Second Call of do. ...	85	17	6			
				189	7	6
Bemrose & Sons, Printing and Stationery...				20	0	2
Sundry Printing and Stationery				2	7	9
Auditors				3	3	0
Reporting Proceedings				7	2	10
Stephenson Memorial Hall Occupation ...				13	13	11
Fire Insurance				0	12	6
Postages, Parcels, and Telegrams				13	11	0
Travelling and Incidental Expenses ...				8	11	6
Requisites and Services				1	1	4
Federated Excursion Meeting at Nottingham and Annual Meeting at Chesterfield				6	7	6
Secretary's Salary, Assistance, and Use of Office; 3 Qrs. at £35, and 1 Qr. at £25				130	0	0
Bankers' Charges				0	12	1
Total Expenditure ...				396	11	1
Balance in Messrs. Compton & Evans' Union Bank, Ltd., Chesterfield, June, 1891 ...	75	14	7			
Less on Account of forward year	46	12	4			
				29	2	3
Arrear Subscriptions...				52	8	0
				£478	1	4

June 22nd, 1891,
Examined and found correct,
THOMAS WILKINSON,
JOHN HALL, } AUDITORS.

Mem.—Certificate of £533 6s. 8d. Midland Railway Company's 3 per Cent. Debenture Stock deposited in Compton & Evans' Bank.

DR. THE TREASURER IN ACCOUNT WITH SUBSCRIPTIONS, 1890-91. CR.

		£ s. d.	£ s. d.
187	Members as per List, 1890-91		
1	Do. did not complete Membership		
186		292 19 0	
	Less five paid in advance last year ...	7 17 6	
			285 1 6
	One formerly Student paid Entrance	0 10 6	
	One Member elected January 1890, paid Entrance	1 1 0	
	Two Members paid in advance, 1891-2	3 3 0	
	Five New Members do. and Entrances	13 2 6	
			17 17 0
7	Subscribing Members		7 7 0
36	Associate Members and Students ...	36 0 0	
	Less one paid last year in advance ...	1 0 0	
		35 0 0	
	Two paid Extra as Members and Entrance	2 4 0	
	One paid Arrear not in List	1 0 0	
	One Associate and Two New Students paid in advance, 1891-2	3 0 0	
			41 4 0
14	New Members and Entrances	36 15 0	
4	New Associate Members and Students	4 0 0	
			40 15 0
18			
247			392 4 6
	Arrears per last Balance Sheet ...	89 3 6	
	Deduct Irrecoverable Arrears not included in 1891-2 List	69 8 0	
			19 15 6
			£412 0 0

		Unpaid. £ s. d.	Paid. £ s. d.
151	Members		237 16 6
5	Paid last year in advance		
30	Unpaid	47 5 0	
186			
	One formerly Student paid Entrance		0 10 6
	One Member elected Jan., 1890, Do.		1 1 0
	Two Members paid in Advance, 1891-2		3 3 0
	Five New Members Do. and Entrances		13 2 6
7	Subscribing Members		7 7 0
24	Associate Members and Students ...		24 0 0
	Two paid extra as Members and Entrances		2 4 0
	One paid Arrear not in List		1 0 0
1	Paid last year in advance		
11	Unpaid	11 0 0	
36			
	One Associate and Two New Students paid in advance, 1891-2		3 0 0
14	New Members and Entrances		36 15 0
4	New Associate Members and Students		4 0 0
18			
247		58 5 0	333 19 6
	Arrears as per last Balance Sheet ...	63 11 0	25 12 6
		£121 16 0	359 12 0
	Irrecoverable	69 8 0	
			52 8 0

June 22nd, 1891.—Examined and found correct,

THOMAS WILKINSON, } AUDITORS.
JOHN HALL, }

£412 0 0

REPRESENTATIVES ON THE COUNCIL OF THE FEDERATED INSTITUTION OF MINING ENGINEERS.

The CHAIRMAN moved that the recommendation of the Council, that the Institution continue in the Federated Institution of Mining Engineers, be adopted, and coupled therewith the Council's further advice that their present representatives on the Federated Council continue to hold office thereon. He was sure they had profited by joining that Institution, and they could not do better than remain a part of it.

Mr. M. H. MILLS (Chesterfield) said he had great pleasure in seconding the resolution. He was sure everyone felt that the Federation had been of immense advantage to their Institution. Of course like all new undertakings difficulties had been met with, as in the publication of the Transactions, but still he thought these difficulties had now been overcome, and that in the future the Transactions would be more regularly received than they were before they were affiliated with the other institutions. He did not think it required any words to show the real value which accrued to that Institution from federation, and he hoped all of them who were in other institutions not yet federated would use their best endeavours to bring those into the Federation as well.

The motion was agreed to.

The representatives on the Council of the Federated Institution are:—

J. Jackson, Esq.	G. Howe, Esq.
G. Lewis, Esq.	M. H. Mills, Esq.
J. A. Longden, Esq.	W. Spencer, Esq.

G. E. Coke, Esq.

The SECRETARY announced new elections by ballot, as follows:—

SUBSCRIBING MEMBER—

Mr. Arthur Gray Dawbarn, Colliery Salesman, 94, Cannon Street, London, E.C.

ASSOCIATE MEMBERS—

Mr. Richard Wardle, Colliery Surveyor, Teversal, Mansfield.

Mr. William Winterbottom, Colliery Under-Manager, Teversal, Mansfield.

STUDENTS—

Mr. Harry Heathcote, Mining Student, Newstead Colliery, near Nottingham.

Mr. Richard Armytage Wade, Mining Student, Pinxton Colliery, near Alfreton.

The CHAIRMAN said he thought one of the best things that Institution ever did was to pass the resolution by which a new President was elected annually. To him (Mr. Jackson) the work of the past year had been exceedingly pleasant and instructive. In vacating that seat he was sure they would all ratify the choice the Council had made by asking Mr. Longden to take office for the ensuing year. They all knew him as a gentleman who had always shown the most active interest in everything appertaining to mining and engineering, and the social good of those connected with those pursuits. He was perfectly confident that they could place in his hands the care and advancement of this Institution. He asked Mr. Longden to take the chair which he would now vacate.

Mr. LONGDEN then took the chair as President for the year 1891-2. He was greeted very heartily, and delivered his inaugural address as follows:—

PRESIDENTIAL ADDRESS.

By Mr. J. A Longden.

I must in the first place thank you for the honour you have done me in electing me to act as President of this Institution for the next twelve months. I do not give place to any in the interest I have uniformly taken and now feel in the Chesterfield and Midland Counties Institution of Engineers, and when I agreed to accept this position, I did so feeling that whilst much depends on the President for the year, yet far more depends on the Council, members, and Secretary, and I am sure we shall all strive to make this one of the best years we have known.

On Thursday, July 6th, 1871, in the Municipal Hall, Chesterfield, Lord Edward Cavendish gave the presidential address at the opening of this Institution. During these twenty years many who were active members have ceased to be so, many who were then unknown have come to the front.

Since the above lines were written we have all heard with deep regret of the somewhat sudden death of our first President. I was on the Continent when I read the account of his death in a newspaper, and not having heard beforehand that he was ill I could hardly believe the report. It turned out, however, to be only too true, and I can here confirm an opinion expressed by one of the London papers, viz., that to see him was to like him "at sight." He always struck me as being an English gentleman of the very best type, and I am sure this Institution owes very much to his kindly guidance and ever ready help in the earlier days of its existence.

Presidential addresses are now so numerous, and as they are not intended to take the form of a "paper," it is not easy to frame remarks which may be "off" the beaten track and yet suitable. With these thoughts in my mind I have decided to address myself to-day more especially to the rising generation.

This Institution was originally designated the Chesterfield and Derbyshire Institute of Mining, Civil, and Mechanical Engineers. We now have a shorter title and I think a better one, viz. :—Chesterfield and Midland Counties Institution of Engineers. Whether we shall ever amalgamate with the Yorkshire Institute, and unitedly form a real Midland Institute, time will show. We have dropped the words, "mining, civil, and mechanical," and adopted the more accurate description of "engineers."

The mining engineers of to-day are engineers of every description rolled into one. We may divide them into two classes; first, those who have consulting practices in towns and whose work lies more with the landlord's interest than with that of the colliery proprietor; and secondly, those who are resident mining engineers located at a group of collieries belonging to the owner. This latter class divide themselves again into two sections; first, those whose fathers are large colliery owners and who only require their sons to take a general supervision, having an abundant and

efficient staff to do the real work; and secondly, those who without any other recommendation than their own intrinsic worth, seek to earn an honest livelihood by means of this most interesting of all professions.

It is to this last class my observations will apply most forcibly.

I suppose no one will dispute the statement that whilst a mining engineer must be a certificated manager, yet all certificated managers are not mining engineers. A skilful pitman with application can and has in many cases not only made himself the holder of a second-class certificate, but he has also obtained a first-class certificate, and by continuing his studies and using his observations and note book, worked himself up to the position of mining engineer.

The question has often been asked in mining papers, Why cannot certificated managers call themselves mining engineers? and as a matter of fact there is nothing to prevent a man calling himself either a civil or mining engineer, but whether other people whom he wishes to influence by the use of the letters C.E. and M.E. will find him equal to his profession depends on his knowledge and their knowledge of him. Some day the Federated Institution may be so constituted that it will be recognized in the same way that the Institute of Civil Engineers is at the present time, and there is no doubt that the letters after a man's name, M.I.C.E., are of greater value in the eyes of the professional world than the plain C.E.

I shall be pleased when the whole of the examinations for certificates of competency are based on one scale so that no one may be able to say it is easier to get a certificate in one district than in another. Local examinations will always have to be held because the mining terms and methods differ so much in various counties. What may be supremely important where the longwall method of working coal is the system adopted, may be of far less value where the pillar and stall system is in vogue.

I received a letter from a solicitor who had been made the director of a colliery company a few months since, asking me whether I could recommend to him a book which would enable him to gain an insight into colliery management, so as to fit him in some degree for the post. I replied that there was no short cut to the attainment of this knowledge, and that he must carefully tabulate the details of his cost sheets, and by comparisons and observations he would in time find out the most important points to watch. Every member of this Institution will, I believe, agree with the answer I gave him as to his obtaining the knowledge he desired.

As a matter of fact, it is curious that there should be hardly any book bearing on colliery management. I buy nearly all the books which are published on coal mining and the kindred subjects, but I do not remember any book which gave me any hints on the management of collieries from the standpoint of an owner. All the books published deal with mechanical appliances and the geological and mining sides of the question.

The reason is not far to seek; no two pits are alike, and each pit though working the same seam is surrounded by different circumstances which, all of them, cause comparisons to be almost impossible.

Depth of shaft, thickness of seam, inclination of strata, nature of floor and roof, hard or soft holing, distance of coal-face from pit bottom, wet or dry mine, presence of much gas in the seam, or liability to spontaneous combustion, these and a hundred other questions affect the cost of working, and then the question of quality, distance from market, requirement for the particular coal (house coal not being wanted much in summer, and steam coal not being in great request during times of depression in trade), these and many more details affect the other most important question of average selling price.

I have, as you all know, merely indicated a few of the difficulties which affect the successful management of collieries.

When parents intend their sons to be clergymen, officers in the army or navy, lawyers or doctors, they always decide the question long before the boys leave school or college, and cause their studies to be specially directed to the profession they will ultimately follow. My impression is that the time is rapidly coming when similar educational preparation will be absolutely necessary for mining, civil, mechanical, and electrical engineers.

By the passing of successive Acts of Parliament for the better regulation of the mining industry, the difficulty of obtaining a certificate is increasing, and bearing in mind the yearly closing of small collieries, and the annual development of large coal-fields involving large expenditure, deep sinkings, and great engineering skill, there cannot be two opinions that the future mining engineer will have to be more highly educated than many of those who have been successful in the past. I do not wish to disparage the knowledge of dead languages, but where time is limited and money not plentiful, French and German will be of more assistance to the mining engineer than Latin and Greek. Algebra, Euclid, trigonometry, chemistry, and mechanics, including drawing, are as essential to the future of our profession as the three R's are to the intellectual well-being of the working man.

One of Her Majesty's Inspectors of Mines recently said he did not care what it cost to produce ventilation so long as there was plenty of it. From his standpoint no doubt he was correct, though I feel sure even he would not like this remark to be interpreted in its broadest sense, because as an Englishman, he has an interest in lessening the waste of our national resources, and my impression is that so far as fuel is concerned there is not the life in our coal-fields that many people think.

A boy who takes an interest in Euclid has a thoughtful mind; well nearly all the engineering problems and formulæ are now expressed in algebraical signs, and some are impossible to work out by the old rules of arithmetic. Trigonometry, mensuration, and surveying I need not say a word about, as every member of this Institution knows full well the difficulty of getting an accurate plan of the surface, and another accurate plan of the underground workings, and then the greatest difficulty of all arises how to fit the one on to the other so that the relative position of each is absolutely correct. The difficulty is increased by the necessity for a constant checking of the meridian, as it varies each day of each year, and more at one time than

another. The allowances in measurements that have to be made for an undulating surface, and for a steep mine, the lengthening by stretching and shortening of the chain through getting bent, the liability to expansion or contraction in the paper on which the plan is made, these and a host of other difficulties rise to the mind of each mining engineer who has had much experience with colliery plans. I may mention a case that occurred recently, where, through the meridian being incorrect on the plan in question, the workings were really 45 yards farther from some old workings full of water than the plan showed. If this mistake had been the other way about the colliery in question would have been flooded and probably closed.

The next subject mentioned is chemistry. Whilst this has not played so important a part in the past as it ought, there is no doubt the time has come when it must be much more largely employed. I recently heard of a colliery owner who is making £10,000 a year by the utilization of the bye-products from his coking plant; and the years are not long past when men in Derbyshire by applying greater heat in smelting extracted the silver out of the lead ore, which in the past had been deposited on the bind heap as refuse, and lost. Where will the practical chemist be when coal becomes so scarce that the millions of tons of slack now annually buried in the pits are sent out and sold? Even now, the knowledge of the number of cubic feet of gas and its illuminating power, and the percentage of coke, etc., in gas coal, is absolutely necessary to the gas engineer, and it is equally necessary for the blast-furnace engineer to know the percentage of sulphur and ash in his coke.

I have assumed in all this that the mining engineer deals only with coal, but you know this is not so; he has to deal with large tracts of ironstone, limestone, and all other kinds of minerals. Is there any need to remind Derbyshire men of the immense fields of ironstone which lay exposed to everybody's sight, and yet were of no recognized value till within the last fifteen years? I mean those in Northamptonshire, Leicestershire, Rutland and Lincolnshire, and is not the same thing going on in other industries? The chemist is rapidly becoming a necessary adjunct at all large works.

The last subject mentioned was mechanics. What a range of thought this conveys to the mind? This science divides itself into two parts—statics and dynamics. Statics deals with the practical question of pressure, resistance, stability, gravity, strength of and construction of materials. Dynamics, on the other hand, is another word for the theory of force or power, and has to do with all the calculations so frequent in the experience of the mining engineer when laying down new machinery to raise coal, or to pump water, or to cause ventilation, etc.

We will now assume that all these eight subjects have been thoroughly well mastered at school or college by the young man who intends to be a mining engineer.

A large estate agent wrote to me lately saying he wished to place his son in our profession, and asked my advice. I told him his son must be in daily attendance at

a mine for five years, and at the end of that time the amount he knew would not depend on the teacher but the learner. I have heard no more from that gentleman, not even an acknowledgment of my letter, though he was an entire stranger to me.

If a man thinks he can become a mining engineer by running round the pit so many hours a day he is vastly mistaken.

As soon as he is articled he will probably spend a year practically in the mine with the undermanager or deputy, seeing all kinds of work in the mine, and becoming practically acquainted with every phase of a pit's workings. Some portion of this time must be spent with the night shift seeing roads repaired. He may spend the next year in the drawing office, becoming well versed in levelling, surface and underground surveying, plotting and scaling. A third year he may spend among the mechanics, seeing all kinds of new work laid down and repairs executed; he should ascertain where new sinkings are going on, and get permission to visit these, and see all kinds of sinking operations performed. A fourth year he can profitably spend in gaining an insight into the commercial management of the collieries, obtaining information as to costs and selling prices, etc., and in the fifth year he should acquire such a knowledge of leases and what may be termed the imperial part of the mining engineer's education, that he may be well equipped when he has to act for himself without any other assistance. During the whole of the five years he must, however, spend a good portion of three days each week in the mine, as practical knowledge is everything when a situation has to be obtained; and he must be prepared to devote some time, not less than an hour each night, to thoughtfully reading the many subjects comprised in our profession.

We will now assume that the young mining engineer has obtained his first-class certificate, and is appointed a manager to a new company with a large coal-field which he has to open out from the sod. Let me tell him that all the great movements in the world's history have been brought about by enthusiasts, and the very fact of their being such has caused them to make many mistakes, but as we all do our work more or less through mistakes, and the boldest and most successful through their very activity probably make the most mistakes, so he must not be afraid of owning when he is in the wrong; he will do well to ask other people's advice before expressing his views; most certainly, if possible, should he ascertain the opinion of the man who has the work to do, before deciding what is the best way of doing it.

Through a defective oak curb having been put in a shaft below 100 yards of tubbing, the whole feeder of 800 gallons a minute burst out and ran down into the dip workings of the mine for several days; the sinkers told the manager that it was a mistake to put the oak curb in, but he refused to be ruled by their opinion.

Through the "opening off" stalls not being properly packed with dirt in a long-wall pit the arching at the pit bottom crushed in three times, and if the pit had not been a deep one the creep might have reached the tubbing and drowned the mine. This costly result was a serious mistake on the part of the manager.

A merchant in London said to me the other day, "your coal is quite different from

what it used to be; it is quite a bright, good-looking coal now, and before it was streaky and dull." It was not my business to tell him that the coal was the same, but the dull coal was the face coal, which it was impossible to avoid getting when first opening out, and the bright, good-looking coal was the same coal got on the end. The difference of price at the present time between the two is probably a shilling a ton, and in bad times the dull, streaky coal would very likely be unsaleable.

What increase in the getting price has been caused by a manager not leaving a little more barrier, and thus bringing on to himself a permanent charge for pumping water, which might easily have been avoided? What more annoying expense when it can be avoided than a pumping engine? When mines now working are exhausted, I am afraid we shall have numerous cases of deep pits having to deal with large quantities of water in the seams, and the question will then arise, what is the best power to employ to raise it, steam or electricity?

It is not my intention to enter into the details of colliery management or we might be here all night, but before passing on to another subject I may say great consideration is necessary for the spiritual and moral welfare of the workmen.

If a mining engineer is to be a successful colliery manager he will have to learn that there is a time to speak and a time to be silent. His success will be largely in proportion as he is wise in this matter. He will soon find that whatever he does, though quite unconsciously so far as he himself is concerned, will influence everybody else. Whilst not familiar with his men he must be friendly, and his care for his men's lives should always be the first consideration. He will find it advisable to take an interest in their social well-being, attending their club dinners, helping in their amusements, if possible providing attraction for them at workmen's clubs.

The St. John's Ambulance Society for giving first aid is now so well known that it need not be further mentioned than to say that it is an essential at all well-regulated collieries.

I have not dealt with the question of profit and loss, because it must be evident that if a man cannot make a colliery pay when his neighbours are not losing money he must sooner or later make way for someone else to take his place.

The secret of successful colliery management is personal attention to details, all other things being equal.

I return now to the point I started with, viz., every holder of a first-class certificate is not therefore a mining engineer. I said the fifth year of a young man's pupilage might be spent in acquiring a knowledge of the imperial part of his profession, and in that year he will probably get the information which in my opinion largely helps to constitute him a mining engineer.

First, from a mechanical point of view, he will have to design and construct all kinds of plant in use and likely to be of use at collieries. He must know and be able to explain to his employer the reason why one system is better than another, one machine better than another, one method superior to another, and whilst competition to-day enables him to get various designs and estimates which will by

comparison save him much time and trouble, yet the choosing and ultimate success or otherwise remain with him, and by his cost sheet he will be judged. In saying this I do not wish to convey that low cost is everything, though it certainly in bad times appears to be almost everything. In this age when every ingenuity tends to reduce labour, the mining engineer is apt to forget that a trivial breakdown in an apparently unimportant machine stops the pit, and to a certain extent the less machinery there is at a pit the less likelihood there is of a stoppage in the coal turning.

No colliery or engineering works should be visited without careful notes being made, if not at the time, certainly before the day closes, and whilst everything that has been noted is fresh in the memory. These notes should be indexed for future ready reference. This habit not only refreshes the memory and ensures accuracy, but causes the constant habit of mentally noticing everything of an unusual character that you see, and it is astonishing how many years after you have seen an appliance, the time comes when such knowledge becomes of personal advantage.

You have to convey coals in the mine and have to decide whether the power to do this should be furnished by putting boilers and engine in the pit, by taking steam down the shaft in steam pipes, by taking compressed air down the pit, by taking power down the pit by means of ropes worked on the surface, or by generating electricity on the top, and sending that in cables down into the mine. A hundred men may have written and spoken on the relative merits of each, but the personal pronoun I has to decide and carry out and be answerable for its success or otherwise, both as to first cost and ultimate economical working. This is one of the cases where the man who is a mining engineer shows himself to be such.

As a rule it is not wise to be the first to try a new invention on a large scale.

A certain well-known engineer many years since made a most elaborate report on haulage, and concluded that the endless chain was the best method to adopt, all things considered. I do not think he would say so now, because more improved methods exist at the present time.

We will now consider the question of leases. How many collieries have been virtually spoiled through having taken the coal with such heavy minimum or wayleave rents attached that the payments have become a huge incubus? What does it matter what the acreage rent is if the minimum or certain rent is so high that you can never overtake the fixed rent?

The Commission on Mining Royalties has opened the eyes of many to the enormous wayleave rents now paid on some coals. It is quite a common thing for colliery proprietors to have from £20,000 to £60,000 lying dead in over-paid rents or coal purchased. In many cases there is no possible chance of the whole amount being redeemed or worked off by the present owner. A mining engineer will be called upon to act sometimes for a landlord, and the terms he will draft for a lessor will be very different to those he would prepare for a lessee. I know one gentleman who makes his pupils draw up a lease from each standpoint, and the practice is one to be commended to thoughtful minds.

But perhaps the most important question of all is the life of the colliery. Here the capabilities to get and draw the coal come in, the power to dispose of it profitably, the distance you can convey it to the bottom economically, the annual area you can work out of each of the properties and each of the seams, the number of years you are likely to be able to maintain the output satisfactorily from a commercial standpoint, and the relative bearing of each lease on the other, especially referring to the number of years for which each is held, and the direction of your underground roads, carefully considering the question of possible payment for wayleaves when all the coal in some small plot is worked out or paid for.

The geographical position of a colliery is very important. What an enormous advantage the one has with sixpence per ton less rate to the market than the other! What gain will the one get over the other which comes within the radius for which threepence less is charged for wagon hire? Or, possibly more important still even, what enormous advantage has the colliery which is in connexion with four railways over the one which has only one railway! On this point a large colliery owner said recently to me that he considered the benefit of having four companies to carry his coal compared with one only was equal to fourpence a ton profit. Yet, I am afraid that would be rather difficult to prove satisfactorily at the year's end in the balance sheet.

I have not touched on the method of working the coal; but there is only one opinion in this district, viz., that the longwall is the safest, cheapest, and best every way. There are two of our members who reside in the Leen Valley, who are eminent authorities on this method of coal-getting, and we should welcome a paper on this subject from either or both of them, even though it might be to some extent a reprint of a book that, I believe, cannot now be obtained.

Let me refer to a most interesting meeting which took place on the 17th of this month in London, when the Prince of Wales conferred on many foreign *savants* the honorary diploma of member of the Royal Institution, in celebration of the centenary of Michael Faraday's birth. Not a quarter of a century has passed since his death, yet, curiously enough, on my looking in the *National Encyclopedia*, published in 12 volumes, in the year 1849, I find no mention of the name of Faraday. Foley's chisel has produced a life-like statue of this kindly man, who always made his lectures so interesting and instructive that his pupils loved him, and through his earnestness and perseverance, no doubt, gave to the world many years sooner than it would have been given the valuable information contained in *Experimental Researches in Electricity*. A writer says that in good books you have the best thoughts of the best men. This is eminently so in Faraday's greatest work.

Will anybody dispute the statement that electricity is in its infancy to-day, although Faraday has been dead twenty-five years?—and yet what a development he would find if he could visit us again. Only this month I read that the language of monkeys will soon become common property through placing a phonograph in a monkey-house, and thus the sounds emitted by the inmates are reproduced and may

be copied by the human voice. This, an insignificant item in itself, is only one of the many curious results which are constantly being brought out as the outcome of electricity.

There is a fortune awaiting the man who can produce electricity in quantity as cheaply as the same horse-power is obtained from coal. This will be done, perhaps, sooner than we think. If fuel is maintained at present high prices, and thus injures other trades, it will gradually become less in demand.

How is it no one can produce an accumulator lamp which will give two candle-power for ten hours, and not be too heavy or clumsy to move about? Here is an opening for an inventive mind, and a fortune behind it to the successful patentee.

These remarks have already gone to a far greater length than I had intended, but you know I have only touched the fringe of the subject. If I have said anything which will cause the mining engineers of the future to be more skilful and successful than their predecessors, we all shall be pleased, and wish them God speed.

Mr. M. H. MILLS thought they ought to thank Mr. Longden for his interesting address. They would have to look to the younger members of the Institution to take up those scientific matters which had been mentioned. To the older members it would be like going to school again, and they would prefer to employ younger men who had studied electricity rather than to go deeply into it themselves.

Mr. WILLIAM SPENCER (Leicester) seconded the vote of thanks, and remarked that in most institutions it was the custom for the new President to give an inaugural address, and there being now so many similar institutions, it became, as Mr. Longden had said, most difficult to strike on new ground. He thought that Mr. Longden had done it and in an original manner. He looked upon the address as a most useful one to the rising generation, and it gave him great pleasure to second the vote of thanks.

The vote of thanks was agreed to.

Mr. LONGDEN said that he was very much obliged. If there was anything he had expressed which would be of use to the rising generation he should be glad. The first paper open for discussion was Mr. George Lewis's paper. He believed there were a number of gentlemen present prepared to speak, and if they could give any further information as to the minerals in the neighbourhood of Nottingham they would oblige a great number of interested persons.

Mr. W. SPENCER said that before the discussion commenced he thought they should pass a vote of thanks to their late President. Mr Jackson, as they all knew, was a very busy man, but he had devoted a great deal of his time to the service of that Institution, and he thought that for many reasons he was probably not sorry to retire from the post he had so well filled during the past year. He thought it was an honour to any man to be elected President of that Institution, but that honour,

like all honours, brought with it corresponding responsibilities. Mr. Jackson had been an excellent President, and it was a great pleasure to him to propose the vote of thanks.

Mr. W. G. TURBUTT, J.P., seconded the motion.

The vote was carried with acclamation.

Mr. JACKSON heartily thanked them for recognizing any feeble efforts of his in the way they had done. He could assure them that his term of office had been one of very great pleasure, and he only hoped the little he had done had been to the advantage of the Institution.

DISCUSSION ON MR. GEORGE LEWIS' PAPER ON "A GEOLOGICAL SKETCH OF THE TOWN AND DISTRICT OF NOTTINGHAM."

Mr. G. E. COKE said it would be a pity for this paper to be passed over without discussion. He thought it was an extremely good summary of what was known about the geology of the district. The knowledge of the coal-field south and east of Nottingham was at present derived principally from the two deep borings at North Scarle and Owthorpe. At North Scarle the Coal-measures were reached at a depth of 600 yards, and water from a depth of 400 yards came out at the top of the bore-hole. Mr. De Rance, a great authority on underground waters, considered that this water came from the Trent 9 miles away. The Owthorpe boring was only published to a depth of about 500 yards, though it was carried deeper; the Coal-measures were reached at 366 yards. The overlying measures were thus shown to be thickening both to the south and east, and as the local dip of the coal was to the north of east, the prospect of finding an extensive coal-field south of Nottingham did not seem very hopeful. Going eastward the seams below the Top Hard showed a tendency to deteriorate, though the Top Hard so far had not shown this tendency; he was inclined to agree with the remark of the President that the available coal-field was not so extensive as was often supposed. Taking into consideration the increasing thickness of the overlying formations, probably heavily watered, the greater depth, and possibly inferior coal, he thought that the best of it was being worked out now. He hoped that some other gentlemen acquainted with the district would give their views.

Mr. M. H. MILLS made a similar appeal, remarking that he saw present Mr. Stokes and others. He was sure that Mr. Stokes could give them a good deal of information, both interesting and valuable. He quite agreed with everything Mr. Coke had said about this matter. There was no doubt that the coal-basin—the Derbyshire coal-basin—was gradually beginning to rise towards the south near Nottingham, and it was a question where the edge of the basin came. That could not possibly be told until they bored and found out. The Top Hard Seam cropped out south of Nottingham, not to the surface, but against the bottom of the upper

measures, and where the lower coals also cropped up against these upper measures could only be proved by boring. He did not think anyone of them had formed any reasonable opinion on the southern extremity of the coal-field, and he therefore thought it was better to say nothing more about it at present.

Mr. A. H. STOKES (H.M. Inspector of Mines, Derby) said as regarded the coal-field of Nottinghamshire, if a line were drawn from Nottingham to Worksop there was very little, if any, coal worked to the eastward of such a line, and the probability was that the county of Nottingham contained one of the largest unworked coal-fields in the kingdom, a coal-field with an area probably of something like 500 square miles of undeveloped coal-seams. He had not yet seen the slightest indication to doubt that the coal-seams extend right away to the eastern boundary of Nottinghamshire. With regard to its deterioration, there were managers of Nottinghamshire collieries present who would, he thought, tell them that the inclination of the Top Hard Seam at the extreme east was a very slight dip, and the quality did not deteriorate. As to the inferiority of the lower seams, he had not seen it as yet. He had compared some of the coals, but had not found much inferiority to similar seams worked in Derbyshire, miles away. He looked on Notts as one of the best coal-fields they had within miles of the town. As to its extension east of Nottinghamshire, well, probably the question might be asked him, "Do you think it extends to the North Sea?" All he said on that point was, he knew of no negative geological feature to indicate that coal did not exist in Lincolnshire. How far the Nottinghamshire coal-field extended towards the North Sea no one knew.

Mr. HUGH BROWNE (Nottingham) thought it was rather extraordinary that they should not know what existed just around them. Some sixteen years ago coal was discovered at Borrowash, in boring for a well, to the surprise of the mining engineers. He thought some organized effort ought to be made to ascertain where the coal-fields extended to. During the Manchester Ship Canal works most valuable beds of salt, etc., had been discovered, and similar discoveries had been made in Durham and North Yorkshire. By sinking, salt had been found in Cheshire; and salt and alum had been discovered in Prussia by similar means. He need hardly remind them of that most important discovery in mining of recent years, that by boring coal had been found in Kent. With these exceptions no efforts had been made towards finding out what was below them, and he thought that an Institution like that should direct their efforts to get some systematic boring taken up. There was another question for consideration, and that was the working of the thinner seams so largely abandoned at present as unprofitable, but of course that was more a matter for the future. And connected with this, he had noticed the illustration of the old dog-cart or truck, which evidently was a former method of getting thin seams. The practice was now prohibited by a law passed thirty-five years ago, which, he considered, was rather a questionable law. They might find that dogs could be used again in seams where they used to be employed and be better and cheaper than ponies. He was not a mining engineer, and simply threw out

these suggestions in the hope that some might be found to be practical. Another matter he might mention was the question as to how far electricity was dangerous underground. Some years ago he held an inquest on a man killed by lightning. The interest in the case was heightened by the effect of the fluid on the clothes he was wearing. The man and his companion were running for shelter in a thunderstorm. The man was struck down and his companion thought he was only dazed, appearing simply to fall down. He was dead. He was wearing a thick felt hat which seemed to have protected his head. His brow was marked where the electricity entered, but what impressed him (Mr. Browne) most was, that the electric fluid having entered the system seemed checked by woollen stockings and came out above them through the linen thread in the seam of his trousers, the seam being torn open. This fact seemed to suggest something as to the importance of clothing, and it possibly might afford a suggestion as to further protection in mines where electricity was used.

Mr. SPENCER, thought he could explain one point in Mr. Browne's remarks as to why people did not go boring about the country and expending their money. Coal mining was chiefly in the hands of private persons, and during some years things had been very bad. During the past three years they had been a little better. An eminent authority had stated that the money in the country employed in the industry of coal mining, had probably not yielded 2½ per cent. There had for many years been rather too much coal in the market than too little; that was, he thought, the reason why people were not disposed to bore in the way named by the last speaker.

The PRESIDENT was afraid Mr. Browne had been chiefly regarding the interest of the landlords.

The discussion was adjourned to the next meeting.

ELECTION OF OFFICERS.

Messrs. WILLIAM WILDE and P. M. CHESTER, who at the commencement of the meeting had been appointed Scrutineers of the voting papers for the election of Council for the ensuing year, presented the result of their scrutiny, which was announced to the meeting by the Secretary.

A vote of thanks was passed to the Scrutineers.

The complete list is as follows:—

PRESIDENT.

J. A. Longden, Esq., Teversal, Mansfield.

VICE-PRESIDENTS.

S. Alsop, Esq., Pinxton, Alfreton.
G. E. Coke, Esq., Corporation Street, Chesterfield.
G. Hewitt, Esq., Unstone, Sheffield.
W. D. Holford, Esq., Whittington, Chesterfield.
M. H. Mills, Esq., Mansfield Woodhouse, Mansfield.
H. Walters, Esq., Birley Collieries, Sheffield.

COUNCILLORS.

W. Davies, Esq., Sheepbridge Works, Chesterfield.
M. Deacon, Esq., Blackwell Collieries, Alfreton.
J. W. Fearn, Esq., Devonshire Street, Chesterfield.
H. Fisher, Esq., Clifton Colliery, Nottingham.
G. Fowler, Esq., Basford Hall, Nottingham.
J. C. B. Hendy, Esq., Pleasley Colliery, Mansfield.
G. Howe Esq., Clay Cross, Chesterfield.
C. H. Oakes, Esq., Holly Hurst, Alfreton.
W. Salmond, Esq., Pinxton, Alfreton.
C. H. Seely, Esq., Sherwood Lodge, Arnold, Notts.
J. B. Smith, Esq., Newstead Colliery, Nottingham.
W. Spencer, Esq., Southfields, Leicester.

Ex-officio { George Lewis, Esq., Albert Street, Derby. / John Jackson, Esq., Clay Cross Works, Chesterfield. } *Past-Presidents.*
H. Lewis, Esq., Annesley Colliery, Nottingham, *Retiring Vice-President.*

TREASURER.

E. Eastwood, Esq., Railway Wagon Works, Chesterfield.

SECRETARY.

W. F. Howard, Esq., Cavendish Street, Chesterfield.

DISCUSSION ON MR. M. H. MILLS' PAPER, "A FEW NOTES ON THE IRONSTONE DEPOSITS OF LEICESTERSHIRE."

Mr. MILLS said that when he made the few remarks contained in this paper he promised that he would, if able, write a paper on the subject dealing with it more fully. He hoped to be able to do so very shortly.

Mr. W. SPENCER hoped Mr. Mills would favour them with a fulfilment of his promise as early as possible.

Mr. J. B. SMITH said he would like to make one remark. In the first part of Mr. Mills's paper there was a statement which rather cast a reflexion on the ironmasters of the Midlands, which was that whilst other ironstone than that obtained from the Coal-measures was used in the North of England in 1838, it was not until 1876 that any ironstone field was worked in Leicestershire. Now, Northamptonshire stone was very similar, and the stone there was worked as far back as 1865. He supposed Mr. Mills referred to Leicestershire exclusively, but as it stood the statement rather cast a reflexion.

MR. MILLS—I meant Leicestershire, not Northamptonshire, which was much earlier.

The PRESIDENT was glad to hear that Mr. Mills would be able shortly to give them a fuller paper on this subject. A gentleman had been nominated that day who would, he believed, be well able to discuss the question of the ironstone fields in the adjoining counties.

DISCUSSION ON MR. HARGRAVE WALTERS' PAPER ON "AN EXPERIENCE WITH EXPLOSIVES USED UNDERGROUND;" MR. M. WALTON BROWN'S PAPER ON "EXPERIMENTS WITH EXPLOSIVES USED IN MINES;" MR. F. S. MARSH'S PAPER ON "GERMANS (FUZES);" AND MR. T. M. W. WALLIS' PAPER ON "THE LOW TENSION SYSTEM OF SHOT-FIRING."

Mr. HARGRAVE WALTERS (Birley), said he would like to state that since writing his paper, which was something like three-quarters of a year ago, in consequence of so much delay in publishing the Federated Transactions, there had been a number of experiments with explosives, followed by discussions, in different parts of the country. Therefore, whatever value the paper possessed before, it had been considerably shorn of its interest, although most of his own statements were borne out by the later experiments.

Mr. A. H. STOKES thought the question a very important one, and one which ought not to be lightly discussed and dismissed. Indeed, before the discussion closed, he would like to have the last paper named on the agenda in the hands of the members. Mr. Walters' paper had been delayed, but it was none the less valuable for that. As regarded explosives in mines, he did not think they had one which was absolutely flameless. With respect to the future explosives, there was a great opening for the chemist to give them one which, under any conditions, would be flameless. He had read of a new explosive which had been tried in France. It consisted of 80 per cent. of nitrate of ammonia and 20 per cent. of dynamite. It was not a strong explosive, but sufficiently strong for the miner. It exploded at a temperature much lower than that necessary to ignite fire-damp. In strength it was something between a lime cartridge and dynamite. He did not know if it had been seen or tested in England, but if they could get such an explosive it would be of very great value. As to germans and fuzes, he presumed it was not generally known that gunpowder fuze at the moment of striking would ignite gas. Yet they had people using supposed flameless explosives or water cartridges, and firing the same by a fuze that would ignite gas should there be any near the hole at the time of firing. Some persons were most particular with regard to opening a safety-lamp to fire a shot (and quite right too), but at the same time overlooked the danger from the use of gunpowder fuze. It was very questionable whether shots that were fired in a mine in which safety-lamps were used ought not, in future, to be fired by electricity. The germans mentioned by Mr. Marsh were sometimes as erratic and lively as a real German. They occasionally flew all over the place, and they were uncertain in the firing. Numbers of accidents had occurred from their use. Mr. Coroner Browne investigated this question some time ago. He condemned them after holding enquiries on men whom he thought to have been accidentally killed from using germans. He did not wish to discuss this matter further at present, but would much like to hear the opinion of others present. He

hoped the discussion on the papers would not be closed until they had the other paper before them. The importance of the subject they could gather from the fact that in his district there were more than two million shots fired every year; and in Great Britain there were more than twenty million shots fired yearly in mines. In reply to Mr. Jackson he could not say what was the percentage of accidents resulting; there were some, certainly.

Mr. H. BROWNE said with regard to the inquests referred to by Mr. Stokes, they also enquired as to the explosives, including coal dust. He thought it was largely owing to societies like this, that the importance of explosives had been recognized. It was one great difficulty they had to contend with. When, as Mr. Stokes told them, twenty million shots were fired per year, it seemed creditable to the management of the mines that they had so few deaths.

Mr. H. WALTERS suggested that there should be some independent experiments. Most of the experiments which had been made had been conducted by agents for the sale of particular explosives, and each of course made the best of his own explosive.

Mr. STOKES—Can Mr. Walters tell us of any explosive that is flameless?

Mr. H. WALTERS said he did not know of one. From his experience he had not seen one. There was in his opinion far more danger to be apprehended when bringing the coal down from igniting small jets or quantities of gas in breaks or slips behind the fall and setting fire to the coal, than of direct explosion. But with very ordinary care it was possible to continually blast with the more modern explosives without risk of explosion, and he did not think there should be much difficulty in producing a safe explosive, considering what has already been achieved. The greatest danger will be from heat and not flame. He had seen red hot coke and charred coal at the base of the hole after a shot had been fired.

The PRESIDENT said that was the drawback which many experienced people who had tried several kinds of explosives, to his knowledge, met with.

Mr. W. SPENCER thought Mr. Stokes' suggestion that the matter should be adjourned and not concluded that day, a good one. He had not had as much experience as some people in that room with the new explosives, but he found roburite very good, and he had never seen a spark from it, nor from the water cartridge of Messrs. Nobel & Co. Mr. Stokes said there was no flameless explosive, and Mr. Walton Brown, Secretary of the North of England Institute, and Mr. Walters, both of whom had experimented largely, agreed with him. This was a very important subject and well worth further experimenting upon.

Mr. H. WALTERS said he did not know whether any gentleman there had noticed an account in the *Colliery Guardian* of last week of some experiments with roburite and several other explosives. To try and explode roburite without tamping was said to be not a fair test; it would, however, represent a blown out shot, and it was quite possible a man might forget to ram a hole. In these experiments flame came out 6 or 8 feet, although roburite was said to have no

flame. If properly rammed it would do its work properly, there would probably be no flame from it, and just the same with any other explosive.

The PRESIDENT said he was in Cornwall two or three years ago and saw the Dolcoath Mine. One of the things which struck him very forcibly was the apparent absence of ventilation in this mine, which was 830 yards deep, and yet they blasted largely with nitro-glycerine. Captain Thomas told him that any stranger entering the mines had intense headache, as the result of the fumes acting on the brain. He happened to be there when the Cornish Mining Institute was holding its annual meeting, and he saw many experiments conducted with roburite. He had not heard whether it had since been used in Cornwall, but so far as collieries were concerned he had read that one of H.M. Inspectors of Mines had expressed the opinion that roburite was flameless. He might be mistaken, but he thought it had been so stated. He had taken more interest in this subject quite recently, as he had been getting up evidence preparatory to being examined by the Coal-dust Commission. He saw that the Prussian Commission had gone into the question very fully, and the Council of the Federation had agreed to accept and publish a translation of the Report of the Prussian Fire-damp Commission; he need not say that would form a valuable adjunct to their Transactions.

Mr. J. W. EARDLEY said last year he saw some experiments at the roburite works with roburite and gunpowder. Roburite had no flame, but the other had.

Mr. T. M. W. WALLIS (Derby) said some experiments had been made in South Wales, conducted, he believed, by Mr. William Galloway. The conditions were made to represent a blown out shot. The explosive to be tested was placed in a boiler with one end open; this was filled with gas and coal-dust, which were mixed by a fan. The most successful preparation was carbonite, which only once flamed, and this exception was said to be explained by an unfired portion of another explosive being left in the hole.

Mr. JACKSON said that many years ago this Institution undertook an enquiry into the effects of coal-dust, etc. The result was a volume of statistics which was exceedingly valuable for reference, and which had been commented upon by the highest authorities. They were told there were many million shots fired in this district every year, that with these shots there was flame, and that if there was gas an explosion would take place. He therefore thought it was for that Institution to take into consideration the suggestion of Mr. Walters, and organize a series of experiments, which should be conducted free from any bias or consideration, other than to find out the best and safest explosive. He for one should be very willing to see some of their accumulated funds expended upon such an important investigation.

Mr. MILLS questioned whether the investigation of this matter had not better come from the Federated Institution. It would be a very expensive affair, for it was no use entering upon it unless they spent a considerable sum. They might put it as a recommendation from that meeting.

The PRESIDENT thought Mr. Mills' suggestion a very good one, and was not at all

sure but that Mr. Jackson's suggestions were equally good. They could easily conduct experiments similar to those conducted in Chesterfield with coal-dust. These experiments cost about £60, exclusive of the cost of publication, and they were very valuable indeed. He considered that his being called to give evidence before the Coal-dust Commission last week was mainly because this Institution obtained such valuable results by their experiments, and in his remarks before the committee he based his statements mainly on the information derived from these experiments; that showed what he thought about their value. They had two suggestions before them, but there was no definite proposal. If someone would make a proposition, and someone else second it, he should be glad.

Mr. JACKSON moved that it be a recommendation from that meeting that the Council should take the matter into consideration and report thereon.

Mr. STOKES said he would like to make a third suggestion. The North of England Institute had published a translation of a number of experiments on explosives which had been carried on in France. It would be a pity if they were to waste time by going over ground which had already been traversed, and he would therefore suggest that before they took any steps they should ask the North of England Institute to allow the translation to be published in the Transactions of the Federated Institution.

The PRESIDENT said Mr. Stokes's suggestion need not interfere with Mr. Jackson's motion. Both could be taken into consideration by the Council.

Mr. J. B. SMITH seconded Mr. Stokes's proposal. As many of these experiments had been already often made it was no good repeating them *ad nauseam* and getting the same results. They wanted to break new ground. If they got these results and studied them, then they could experiment with some other explosives which had not been tried, such as cordite, etc., which was a class of explosive only used for guns as yet. He believed that from this class of explosive the desired results would be obtained.

Mr. JACKSON agreed to his suggestion being included with Mr. Stokes's and the proposition was carried *nem. con.*

The discussion of the four papers was adjourned, and

The SECRETARY was instructed to communicate with Mr. Walton Brown in order to bring the approved suggestions, as above, before the North of England Institute and the Federated Institution.

DISCUSSION ON MR. G. E. SMITH'S PAPER ON "THE S.C.P. MINER'S ELECTRIC SAFETY-LAMP."

Mr. G. E. SMITH (Nottingham) said he was sorry not to be able to bring the lamp before them; he had done his utmost with the makers, but they had not sent him one for to-day's meeting. The paper he had the honour of reading before the Federated Institution in September last was not for the sake of advertisement, in

the meaning frequently given to that word, but for information; not only to give information to them, but what perhaps might be thought a more selfish motive—to obtain information from them as to what they considered an electric safety-lamp for miners ought to be. There was an impression abroad, judging from some of the press notices, that electricity was not a reliable agency in mining. He wished to say that if the same periodic attention was given to electric apparatus that was given to other machinery, they would find electricity not only reliable but a good and useful servant when properly treated. As to this lamp, he had determined not to bring it again before them for inspection until it was complete and had been practically tested by the makers and himself, and he had told the makers so. His desire was to see in the hands of the miners a thoroughly practical and reliable electric safety-lamp, whether an S.C.P. or any other make.

The PRESIDENT alluded to a new lamp which had just been brought out. It had an accumulator, weighed 4 lbs., and cost 14s. He did not know whether the maker would be able to supply lamps at that price. There was some difficulty until the Edison and Swan patent rights expired next year. Until that time arrived there could not be any great reduction in price. Their royalty amounted to about 3s. a lamp, which would have to be renewed three or four times a year.

The PRESIDENT said, he might, however, suggest with reference to the next meeting which it was proposed to hold in the neighbourhood of Alfreton, that they should arrive at Alfreton Station at 8 a.m., and see the Blackwell Colliery Co.'s pits there, and go by the 8·38 train to Teversal. They would there see Silver Hill and Teversal Collieries, and go on at 11·36 to Pleasley Colliery, where cold lunch would be provided. Leave Pleasley 1·42, and arrive at Rowthorne Station 1·48. They would have time to see Hardwick Hall, and leave Rowthorne for Chesterfield at 5·18, or by the 6·16 to Mansfield. Mr. Hendy had kindly undertaken to write a paper descriptive of the plant they would see during the day, and he hoped this paper would be in the hands of the members before October 21st.

Mr. J. C. B. Hendy's paper on "The Stanton Ironworks Company's Collieries" was taken as read.

THE STANTON IRONWORKS COMPANY'S COLLIERIES.

By J. C. B. Hendy.

The President of the Chesterfield and Midland Counties Institution of Engineers (J. A. Longden, Esq.) having invited the members of the Federated Institution of Engineers and the British Society of Mining Students to visit these collieries, the following notes descriptive of the plant and pits and the results of experiments made with the respective fans and electric machinery may be interesting.

The collieries are situated on the Teversal Branch of the Midland Railway, from three to six miles west of the town of Mansfield, in the counties of Derby and Nottingham, lying immediately on each side of the boundary line dividing the two counties. The Pleasley Colliery, near the village of Pleasley, is in Derbyshire, and the Teversal and Silver Hill Pits, near the village of Teversal, are in the county of Nottingham.

The area of royalty held by the company comprises about 7,000 acres, including the estates of Pleasley, Teversal, and a portion of Hardwick, the principal lessors being the Countess of Carnarvon, Sir Harry Verney, the Marquis of Hartington, and the Duke of Portland.

It is expected that the whole of the coal now leased to the company will be worked by the present pits.

The collieries find employment for 1,700 men and boys and 150 horses. The annual output is about 700,000 tons, which, when the Silver Hill and Pleasley upcast pits are further developed, will be increased to one million tons per annum.

The seams worked are:—At Silver Hill, the Low Main and Black Shale, and at Teversal and Pleasley the Top Hard. At the two first-named pits the steep inclination of the seams adds considerably to the working cost, the dip being as much as 9 inches to the yard to the north-east. Between Teversal and Pleasley the inclination gradually changes, the average being at the latter 1 in 12.

About midway between the Teversal and Silver Hill Pits there is a downthrow fault to the east of 180 feet, which, with the dip of the measures, makes a considerable difference in the depths of the several shafts, relatively situate as they are almost on the line of full dip. The depth to the Top Hard Seam at Silver Hill is only 51 yards, whilst at Teversal it is 217 yards, and at Pleasley, 2½ miles farther east, it is 514 yards. The Teversal and Silver Hill Pits are sunk entirely in the Coal-measures, but a few yards east of Teversal the Lower Red Sandstone and Magnesian Limestone appear, the latter increasing in thickness and reaching at Pleasley a depth of about 250 feet. All the seams are worked entirely on the longwall system.

The following are the depths of the pits and thickness of each seam, also detailed sections of the seams now being worked:—

Depth of Pits to each Seam.

Colliery.	Depth in Yards.	Name of Seam.	Thickness of Seam.	
			Feet.	Inches.
Silver Hill	51	Top Hard	5	6
Do.	72	Dunsil	4	0
Do.	109	Waterloo	2	7
Do.	290	Deep Hard... ...	2	7
Do.	300	Piper	2	8
Do.	356	Low Main	4	9
Do.	362	Three-Quarter ...	2	10
Do.	396	Yard Coal	3	4
Do.	418	Black Shale ...	3	1
Teversal	217	Top Hard	5	0
Do.	237	Dunsil	3	9
Pleasley	514	Top Hard	5	1

Detailed Sections of Seams now being Worked.

Silver Hill Pit.

Black Shale—	Ft.	In.
Tops	0	10
Band	0	1
Tinkers	0	7
Band	0	2
Bottom Coal ...	1	5
Total	3	1

Teversal Pit.

Top Hard—	Ft.	In.
Brights	1	0
Bastard Hard ...	0	5
Smooth Hard ...	1	0
Best Hard	1	8
Bottoms	0	11
Total	5	0

Silver Hill Pit.

Low Main—	Ft.	In.
Top Coal	0	11
Bottom Coal ...	3	10
Total	4	9

Pleasley Pit.

Top Hard—	Ft.	In.
Brights	1	0
Bastard Hard ...	0	7
Soft Coal	0	3
Cannel	0	9
Minge	0	5
Best Hard... ...	1	1
Bottoms	1	0
Total	5	1

Results of Tests made with different Coals in Experimental Gas-making Apparatus.

	Silver Hill Wallsend.	Silver Hill Low Main.	Silver Hill BlackShale Cannel.	Teversal Cannel.	Pleasley Cannel.
Cubic feet of purified gas yielded per ton of coal	10,439	9,868	12,332	10,659	11,278
Illuminating power of the gas in standard candles, calculated for a consumption of 5 feet per hour in standard London argand burner with six-inch chimney	18·13	18·2	21·4	21·0	28·59
Percentage weight of dry coke ...	67·88	60·31	55·0	58·98	54·28
Dry coke in lbs. per ton	1,410	1,351	1,232	1,310	1,215

PLEASLEY COLLIERY.

Shafts, etc.—Two shafts, each 14 feet 6 inches diameter. When sinking through the limestone, feeders of water from 800 to 1,000 gallons per minute were met with, and for 117 yards the shafts are lined with metal tubbing, commencing 18 yards from the surface. The thickness of the tubbing is ¾ inch, 1⅛ inches, and 1¾ inches; the top segments being 2 feet 6 inches by 4 feet 6 inches, and the lower 2 feet by 4 feet 6 inches. The downcast pit is fitted with wooden guides (pitch pine) 4¾ inches by 4¼ inches, four to each cage, the guides being bolted to oak cross-stays, the latter being 10 feet apart and fixed into cast iron boxes let into the shaft, and brackets cast on to the tubbing. The middle stays are 9 inches by 8 inches, those at the sides 9 inches by 6 inches.

There are rope conductors in the upcast pit 1⅛ inches in diameter. The top of this pit is covered by two flat "bonnets," which are raised and lowered by each cage on coming to the surface, the bonnets falling on to tight-fitting padded seats.

Ropes, etc.—Round ropes in each pit, all 1⅛ inches in diameter, of pliable plough steel, running over pulley wheels 16 feet diameter, and having King detaching hooks.

Cages and Tubs.—Downcast pit.—Double-decked steel cages, carrying two tubs on each deck; weight of each cage, 53 cwts. The tubs are changed simultaneously at the pit top and bottom. Upcast pit.—Double-decked cages carrying one tub on each deck; weight of each cage, 29 cwts.

Tubs.—Carry 13½ cwt. of coal each, have steel wheels 13½ inches diameter, and 2 feet gauge, with wood sides and sheet iron ends; weight, 7 cwts. Box pedestals carrying sufficient oil to last from four to seven days are being applied.

Winding Engines.—No. 1 pit.—A pair of horizontal engines with 40-inch cylinders and 6-feet stroke. Drum, 20 feet diameter, and 6 feet 10 inches wide, with foot and steam brakes. Double-seated Cornish valves 12 inches diameter, worked by eccentrics from trail cranks. Average speed of piston when coal drawing, 390 feet per minute; steam pressure, 48 lbs. No. 2 pit.—A pair of horizontal engines with 34-inch cylinders and 6-feet stroke, with slide valves. The reversing gear is worked with a steam driver, with 8-inch cylinder and 12-inch stroke. Drum, 16 feet 6 inches diameter and 6 feet 10 inches wide. Average piston speed when coal drawing, 448 feet per minute; steam pressure, 48 lbs. Both engines are in the same engine house, being set back to back. Stauffer lubricators are used on all the engines.

Boilers.—Steam is supplied to the winding engines, belts, and shop engines, etc., from sixteen boilers set on each side of the winding engine house. Nos. 1 to 8 are 40 feet by 5 feet 6 inches, with single tubes 2 feet 10 inches diameter. Nos. 9 to 12, Lancashire boilers, 30 feet by 7 feet, with tubes 2 feet 8 inches diameter. Nos. 13 and 14, Lancashire boilers, 28 feet by 7 feet 6 inches, with 3 feet tubes. No. 15, 31 feet by 7 feet, with 2 feet 9 inch tubes, and No. 16, 30 feet long by 7 feet

diameter, with 2-feet 8-inch tubes. When the engines are at work the boilers are fed by four No. 12 exhaust steam injectors, and when the engines are standing, by a donkey pump with 8-inch rams, and 10-inch stroke. Nos. 1 to 4 are being fitted with Whitaker mechanical stokers. Steam is supplied to the fan and electric engines from a range of four Lancashire boilers, 30 feet by 7 feet, with tubes 2 feet 8 inches diameter, the feed being from a No. 9 exhaust injector, worked by the fan engine exhaust. All the boilers have Caddy patent fire bars. The water supply is pumped from the river Meden by a Tangye special pump, 10 inches by 6 inches by 12 inches, with vertical boiler, which forces 7,200 gallons per hour, against a head of 133 feet. The water contains a large proportion of carbonate and sulphate of lime, and especially after rain is very muddy. To take the matter in suspension out of the water a pair of Torrent filters are placed near the reservoirs, each capable of filtering 4,500 gallons per hour. There is also a duplicate pump and boiler at the pumping station.

Fans.—There are two Waddle fans 40 feet diameter, with 14-feet inlets, driven by separate horizontal engines having 26-inch cylinders, and 4-feet stroke, with slide and cut-off valves. The fans are changed every month, one fan and engine being always kept in reserve. The engines are placed side by side, and the fans on either side of the engine house are 50 yards from the upcast pit. The ventilating current passes from the upcast pit 30 yards from the surface through an air drift, which on approaching the fans divides into two branches, each branch drift leading into a fan pit, up which the air ascends to the fan inlets. The shutters are placed in the branch drifts at their junction with the fan pits, and are raised or lowered by small crabs placed over them. The fans can thus be changed at any time without interfering with the ventilation of the mine.

In the following experiments the diagrams were taken with a Richards indicator, and the air measurements by an anemometer, both of which were specially tested by Messrs. Davis, of Derby. The water-gauges were fixed parallel with the air current, the orifice being about 8 feet from the fan inlet. The air was measured in the main return 20 yards from the bottom of the upcast pit, and also in the fan drift. The quantities of air given are those obtained in the pit, the drift measurements giving about 3 per cent. more useful effect than those in the pit. The coal used was carefully weighed, the fires kept in the same condition, and the water at the same level in the boilers throughout. Time occupied by the experiments, eight hours,

Some years ago Mr. A. H. Stokes, Inspector of Mines for the Midland district, conducted a series of experiments with these fans, the useful effects being then from 36 to 40 per cent. He also made some experiments with these two fans both running at the same time on the mine, similar in character to those recently communicated to the North of England Institute of Mining Engineers by Mr. W. Cochrane. Mr. Stokes would no doubt communicate the result of these experiments if the members desire it.

Experiments with the Pleasley Fans, June, 1891.

No of Experiment	Water-gauge in Pit.	Water-gauge in Fan Drift.	Barometer on Surface.	Barometer in Pit.	Thermometer on Surface.	Thermometer in Pit.	Revolutions of Fan per Minute.	Periphery Speed of Fan in feet per Second.	Cubic Feet of Air per Minute in the Pit.	Horse-power in the Air.	Indicated Horse-power of Engine.	Lbs. of Coal per Hour per Horse-power of Engine.	Lbs. of Coal per Hour per Horse-power in the Air.	Per Cent. of Useful Effect on Air in Pit.	Per Cent. of Useful Effect on Air in Fan Drift.	Lbs. pressure of Steam in Boilers per Square Inch.	Cost of Fuel per Week at 3s. per Ton.
								West	Fan.								£ s. d.
1	1·70	2·0	30·15	31·23	57	70	45	94	69,525	21·9	67·1	7·5	23·0	32·6	34·2	51	5 13 4
2	1·90	2·2	30·15	31·23	58	70	50	104	79,050	27·4	85·0	9·8	30·5	32·2	34·5	50	9 9 0
3	2·30	2·7	30·15	31·23	57	70	55	115	87,825	37·3	116·0	8·2	25·5	32·1	35·0	52	10 14 0
4	2·80	3·3	30·15	31·23	61	70	60	125	95,625	49·7	142·0	7·0	20·2	35·0	37·4	54	11 6 9
								East	Fan.								
1	1·20	1·65	30·54	31·48	58	70	45	94	74,425	19·3	66·0	7 6	26·6	29·2	32·0	53	5 13 4
2	1·80	2·05	30·54	31·48	60	70	50	104	81,450	26·3	87·5	9·0	30·0	30·5	33·1	52	8 16 4
3	2·00	2·30	30·54	31·44	80	70	55	115	86,325	31·2	118·0	7·5	28·0	35·6	37·4	54	10 1 0
4	2·60	3·05	30·51	31·40	91	71	60	125	93,225	44·8	149·0	6·7	22·5	30·0	33·0	56	11 6 9

Cost per week for oil, waste, etc., fan at 50 revolutions per minute, 3s. 9d.

Natural ventilation measured after fan had stood two hours, 28,000 cubic feet per minute.

Belts, Screens, etc.—Until recently the coal sorting and cleaning has been done on two sorting belts and screens, one on each side of the pit. These belts were amongst the earliest of the kind put down in the district, and consequently without many of the improvements effected during the past few years in similar arrangements. The proportion of slack and small made became very excessive, owing partly to the wearing and bending of the plates and angle irons at the edges, and in a great measure to the fact that the belts were too narrow for the quantity dealt with, the coal in consequence grinding very much against the sides. As it was found that the cost of repairing this plant would be at least £500, it was decided to erect a new sorting belt, with elevator and screens complete, capable of dealing with the entire output, viz., 180 tons an hour, and keep the old plant ready for work in case of any temporary stoppage or breakdown.

The dimensions of the old belts are:—North belt, 110 feet long by 2 feet 9 inches wide. Engine, 12-inch cylinder and 2-feet 6-inches stroke. South belt, 150 feet long and 3 feet wide. Engine, 16-inch cylinder and 3-feet stroke. Both engines have pinion and spur wheel gearing, the belts being driven by the Ley patent chains and pulleys.

The new belt is erected on the south side of the pit, the sorting and cleaning being done on each side of the belt, and the remaining coal carried to the screens by the elevator. The different kinds of coal made are:—Hand picked off belt: large brights, London brights, steam, best hard, burgy and cannel. Made on screens: cobbles, nuts, nut slack, and dust.

This belt is 200 feet long from centre to centre, and 4 feet 6 inches wide, made of mild steel plates $\frac{1}{4}$ inch thick by 4 feet 6 inches by 15$\frac{1}{2}$ inches, overlapping 1$\frac{1}{4}$ inches at the joints, and riveted to the chains by six rivets in each plate. There are three solid forged link chains with double links, $\frac{3}{4}$ inch by 2$\frac{1}{4}$ inches, and single links 1$\frac{1}{4}$ inches by 2$\frac{1}{4}$ inches, the joint rivets being $\frac{3}{4}$ inch. Six octagonal drums give motion to the belt, bored and fitted to 5-inch shafts, the trail end working on two adjustable pedestals, with screws of sufficient length to take up two links of the chain. The frame consists of cast iron standards every 8 feet on each side of the belt, with cross stretchers from standard to standard, and angle iron guides for top and bottom 3 inches by 3 inches, an additional line of angle irons fastened along the top forming a ledge and side for the trough of the belt. The belt is carried on rollers running under two of the chains and placed every 4 feet for the top or loaded side, and every 8 feet for the bottom or returning length. The speed of the belt is 65 feet per minute.

The elevator is 4 feet 6 inches wide, with pan buckets on a three-chain belt similar to the sorting belt, turning on six hexagonal drums, with adjustable pedestals at the bottom. The elevator frame is of lattice structure with underneath shoot plates to prevent scattering of the coal, and is carried at the bottom on a cast iron frame bolted to the brickwork. The top of the elevator and also the screen is carried on four sets of metal columns connected with H-section girders. The driving drums

have steel driving fingers fitting into a slot and fastened at the back by a cotter, so that the fingers can be renewed when worn.

Engine and Gear.—An engine with 16-inch cylinder and 30-inch stroke drives the belt and elevator, the belt being driven from one end of the shaft and the elevator from the other, the latter by a 12-inch pinion working into a 4-feet wheel, which is fitted to an upright shaft 4 inches diameter, supported by bushed footsteps. On the top of this shaft is a 12-inch pinion working into another 4-feet wheel on the shaft of the elevator drums.

On the driving drum shaft of the belt there is a bevel-wheel 7 feet diameter, working into a steel pinion 1 foot 6 inches diameter on a 4½-inch main counter-shaft. On this shaft is another gearing-wheel working into a steel pinion, keyed on the engine shaft.

Screens.—The screen is supported by H-irons on metal columns, has a fall of 6 inches to the foot and is 4 feet wide, with channel iron sides 12 inches by 3 inches, to which are attached dead plates ⅜ inch thick. Beneath the screens are two hoppers, one for nuts and the other for nut slack, provided with doors and slides 2 feet square, and made of ⅛ inch plates on angle iron frames. At the top of the screen the dust is taken out by a perforated plate, 3 feet 9 inches by 1 foot 8 inches, the dust running down an iron box into the fireholes. The cobble bars are 6 feet 6 inches long, and the nut bars 9 feet 4 inches long. At the foot of the screen there is a travelling belt 24 feet long and 4 feet wide, on to which the cobbles fall and are cleaned, this belt delivering the cleaned coals on to a shoot, off which they fall into the trucks after being finally screened. This belt is driven by a little engine placed by its side with an 8-inch cylinder.

Tipplers.—The Fisher double side revolving tipplers are to be used, there being two of them. The tipping stag is one the level of the top deck, the full trams being taken from the pit to this stage by creepers. A creeper also takes the empties back to the top deck, the empties running to the bottom deck down an incline with chain stops. The creepers are all driven by one engine, with 10-inch cylinder, and are made of single and double linked chains with driving fingers on the single links, the chains running in iron channelling. The whole of this plant is covered with corrugated iron roofing supported by metal columns. The cost of labour has been reduced ¼d. per ton by the new plant, and it is estimated that the total saving effected, including the less proportion of slack and small made, will pay for the whole outlay in twelve months. The present arrangement is equal to an output of 1,600 tons per day of 9 hours, the quantity now being dealt with from 1,000 to 1,200 tons, and the cost per ton for banking, screening, sorting and cleaning, etc., 3d.

Electric and Underground Haulage.—A straight main road three-quarters of a mile in length has been made from near the pit bottom to the rise side of the mine, and the coals are brought down this road by a series of self-acting inclines. No. 1 incline, 1 in 12, and 450 yards long, running 16 trams a time; No. 2, 1 in 9, and 340 yards, running 16 a time; and No. 3, 1 in 6, 260 yards long, and running 8 trams.

To bring the coals from the dip a large electrical haulage plant has recently been erected by Messrs. Crompton, electrical engineers, London, and commenced to work at the beginning of the present year. This installation is capable of giving 60 horse-power at the motor. At the present time it is working an endless rope in the north-east main road for a distance of 450 yards, which will shortly be lengthened to 850 yards, hauling from 400 to 500 tons per working day of 9 hours, the average dip of the road being 1 in 12. As the workings advance, however, this rope will be lengthened to over a mile. It is also intended to work, at the same time, a branch endless rope in the north district a mile long, as well as pump the water from the dip workings by a pair of 6-inch pumps, placed 400 yards from the motor and worked by the same endless rope. The distance between the dynamo and motor is 725 yards, the former being on the surface, in an engine house erected by the side of the fans, and the latter underground, 80 yards from the upcast pit, in an engine house by the side of the main road, in such a position as permits the ropes to bring the trams to either top or bottom deck. The dynamo is worked by an old horizontal engine, with 20-inch cylinder and 3-feet stroke, having a fly-wheel 13 feet diameter, and driving pulley 12 feet diameter, and 18 inches wide, the latter driving a pulley 2 feet 5 inches diameter, on a counter-shaft, by a patent Lancashire belt. The dynamo is driven by a belt of the same description from another pulley, 5 feet diameter on the counter-shaft. The speed of the engine is regulated by a double-seated equilibrium valve, with governors worked by belting from the main shaft. The dynamo has been tested to 606 volts and 140 ampères, and the motor to 536 volts and 140 ampères. Both dynamo and motor are mounted on rigid cast iron bed-plates, and are provided with three pedestals and bearings, the pulleys being carried between two bearings. The bed-plates rest upon two cast iron rails, upon which the machines can be moved so as to tighten the belts if necessary without stoppage. The foundations for the dynamo, etc., consist of pitch-pine balks 14 inches by 14 inches built on to solid brick pillars. The magnets are of wrought iron, the coils being wound on suitable formers slipped on to the magnets. The armatures are soft wrought iron discs, mounted on a steel shaft, 3¼ inches diameter, running from end to end through the three bearings. The driving pulley on the dynamo shaft is 22 inches diameter. The windings of the armature and magnet coils are of copper, insulated, and of 98 per cent. conductivity.

The motor is shunt-wound, and the dynamo compound-wound. There are three carbon brushes, on either side of the commutators, each 2 inches wide. In the main circuit, near the dynamo, are two safety fusible cut-outs, which fuse at about 140 ampères. Ammeters and voltmeters are placed near the dynamo and motor. The main roads leading to the bottom of the pits are lighted by twenty-four Swan incandescent lamps of 16 candle-power, arranged four in a series, the current being taken from the main cable for them. In the motor house there are four 16 candle-power lamps, and five in the dynamo house. There is a resistance frame and switch near the dynamo, by means of which the man in charge can regulate the E.M.F.

and prevent the volts rising to such a height as would break the lamps. The motor is also used in conjunction with another resistance frame, by means of which the speed can be regulated, the motor being stopped or started by a switch. The motor and dynamo shafts are lubricated by Crompton patent sight-feed lubricators, and the pulley bearings by Stauffers.

The cable consists of nineteen copper wires of 15 B.W.G., having an insulation resistance of 300 megohms per mile, the insulated cable being 1 inch in diameter. It is taken from the dynamo to the motor down the upcast pit, in pitch-pine casing 6¾ inches by 2 inches, the cables being laid into two grooves made in the casing 2½ inches apart, after which covers of pitch-pine 6¾ inches by 1¼ inches are screwed on with 3-inch brass screws. The casing is fastened to the shaft side by 6-inch brags driven into wooden plugs, every 4 feet.

The motor and driving gear are placed in an engine house 49 feet long, 17 feet 6 inches high, and 14 feet wide, arched with brickwork 2 feet thick, the end walls being 18 inches. It is of the utmost importance that this machinery should be kept perfectly level and true, and as it was feared that the floor of the engine house might at some time lift, through creep or weighting, it was not fixed on foundations built on the floor, but on to five strong cast iron girders, 15 inches by 18 inches, placed across the engine house, and built into the sides of the arching, the bed-plates being bolted transversely on to these girders. Motion is given to the gearing from the pulley on the motor shaft, 18 inches diameter, from which a patent Lancashire belt runs on to another pulley 12 feet diameter, and 16 inches wide, a pinion wheel 16¾ inches diameter on the shaft of the latter working on to a spur wheel 12 feet 5 inches diameter. The ropes are moved by two 6-feet grooved driving pulleys, with four grooves each, on the spur wheel shaft, with clutches for throwing in and out of gear. At a distance of 12 feet from the driving wheels are two grooved tightening pulleys, each hauling rope passing three times round each pair of driving and tightening wheels The latter are fixed on movable pedestals, and the ropes can be tightened at any time by a wheel and screw arrangement connected to the back of these pedestals. Fisher hauling clips are used on the engine plane, the trams being drawn in twos. At the end of the plane the rope returns around a 5-feet wheel, fixed on a bogey, set on rails, and attached to a balance weight working into a small pit. Cup pedestals are used for the rollers, on the engine plane, which hold grease enough for three or four days. The engine plane is fitted with electric signals, and communication is made between the dynamo and motor by a telephone and electric signal.

The table on the next page gives the results of experiments made with this plant.

The percentage of losses and horse-power of each are :—

Engine and large pulley ...	7·4 H.P.	=	20·9	per cent.
Dynamo, cable, and lights ...	14·7 „	=	41·5	„
Motor	2·3 „	=	6·5	„
Gearing and empty rope ...	7·1 „	=	20·1	„
Load	3·9 „	=	11·0	„
	35·4 „		100·0	

PLEASLEY ELECTRIC HAULAGE PLANT, JULY, 1891.

	Revolutions of Engine per Minute.	Revolutions of Dynamo per Minute.	Revolutions of Motor per Minute.	Speed of Rope in Miles per Hour.	Dynamo. Volts.	Dynamo. Ampères.	Indicated Horse-power of Engine.	Electric Horse-power given out by Dynamo.	Electric Horse-power at Motor.	Pressure at Boilers per Square Inch.	Ratio per Cent. between Horse-power supplied to Motor and Horse-power given out by Dynamo.	Ratio per Cent. between Horse-power supplied to Motor and Indicated Horse-power of Engine.*	Ratio per Cent. between Horse-power given out by Dynamo and Indicated Horse-power of Engine.
Plant running with load of twelve full trams and twelve empties on rope ...	57	650	570	1·72	415	28	35·4	15·57	14·6	52	93·7	41·2	44·0
Engine, dynamo, motor, and empty rope	57	660	585	1·77	405	23	31·5	12·48	11·6	50	92·9	36·8	39·6
Engine, dynamo, and motor	58	660	560	...	412	10	24·4	5·5	5·2	48	...	...	22·5
Engine, dynamo, and lights	58	670	...	...	410	...	22·1	...	...	50	...	...	...
Engine only, with large pulley ...	58	...	...	...	...	...	7·4	...	...	50	...	...	...

Weight of 12 full trams = 12 tons.

Do. do. empties = 4 tons 4 cwts.

* It should be noted this is not an economically constructed engine, but an old one which sank one of the pits sixteen years since.

Sixty per cent. of the power put into the driving belt at the engine is transmitted to the motor, and 52½ per cent. of the same is given out by the motor.

The above load was twelve full trams only on the endless rope, which were in part balanced by twelve empty trams running at the same time. It should be remarked that as this plant is not yet doing anything like the duty it is equal to, and will shortly have to do when the other haulage roads, etc. are ready, the useful results given above, although satisfactory so far as they go, are not so good as it is expected they will be, when, for instance, the motor works up to 40 or 50 H.P. instead of 15 H.P. as at present. Twelve horses have already been dispensed with, and the work was so hard which these horses did that they could not be kept in condition for many months together.

The company have built 102 houses at this colliery, and have also built schools and a workmen's club, and provide the services of a resident curate for the benefit of their workpeople.

TEVERSAL COLLIERY.

Shafts, etc.—Downcast pit, 14-feet diameter, with rope conductors, 1¼-inches diameter, four to each cage. Iron cages with two decks and two tubs on each deck; weight of each cage, 45 cwt. There are two decks at the top and bottom of the pit, the tubs being changed at the same time on each. Ropes, mild steel, 1½-inches diameter, with King detaching hooks. Coals are drawn at the downcast only. Upcast pit, 11 feet diameter; one cage only in this pit, with rope conductors, 1-inch diameter.

Tubs.—Weight, 6 cwt., carrying 11 cwt. of coal, and open at one end. Wheels, 12-inches diameter, steel, and 18½-inch gauge, with outside box pedestals holding sufficient oil to last three or four days.

Winding Engines.—Downcast pit, a pair of horizontal engines, with cylinders 30 inches diameter and 5-feet stroke, with slide valves; drum, 14-feet diameter. Average piston speed when coal drawing, 275 feet per minute; steam pressure, 48 lbs. per square inch. Upcast pit, a pair of horizontal engines, with 18-inch cylinders and 3-feet 6-inch stroke, geared, and drum 9 feet diameter.

Belt, Screen, etc.—A new belt and screen, etc., was erected at the beginning of last year, in place of the old dock system of banking. This belt is 160 feet from centre to centre, 4 feet 6 inches wide, with similar foundations, and of the same construction as the belt described at Pleasley. The coals are tipped directly on to the belt by Fisher tipplers, the sorting and cleaning being done on each side, and the remaining coals raised to the screen by a bucket elevator, 42 feet long, with pan buckets, 9 inches deep, on a three-chain belt of similar construction to the main belt.

The belt and elevator are driven by a horizontal engine, with 16-inch cylinder and 30-inch stroke, the gearing being interchangeable with that at Pleasley. The belt travels at the rate of 68 feet per minute. The full trams are lowered from the top deck to the lower deck level by a counterbalance cage, where all are weighed, and

then run on to a creeper 48 feet long, by which they are taken to the tipping stage, the empties being lowered again to the bottom deck by another balance cage near the tipplers. The creeper is driven by an engine with 12-inch cylinder, with double gear, viz., two 12-inch pinions and two 4-feet spur wheels on 4-inch shafts.

The screen is 48 feet long, falling 6 inches to the foot, with two hoppers underneath for nuts and nut slack. The nut bars are 8 feet long, and the nut slack bars 11 feet long; the dust will be taken out in the same manner as at Pleasley. At the bottom of the screen there is a horizontal picking plate for cleaning the cobbles; from this plate the coals fall down a movable shoot into the trucks. The whole is covered by corrugated iron roofing on metal columns. Before this plant was erected the full trams were run by hand on to the pit bank, and the large coal hand-picked out of the tubs into the trucks, after which the tubs, with the remainder of the coal left in them, were taken up to the screen by a creeper and tipped. The cost of labour by the new plant has been reduced ¼d. per ton, the cost per ton for banking, screening, sorting, etc., being now 3d., and the saleable quality of the coal greatly improved. The percentage of slack, however, has not been reduced.

Fan.—Waddle, 30-feet diameter, with 12-feet inlet. Engine, with cylinder 24-inches diameter and 3-feet stroke. This fan has been at work upwards of twenty years, and the casing and vanes have become very thin. A new Capell fan is therefore being erected, 16 feet diameter and 6 feet 6 inches wide, with single inlet, which will be driven by a pair of vertical engines with 18-inch cylinders and 15-inch stroke, working direct on the fan shaft. It is hoped that this fan will be at work when the members visit the collieries, and the comparative results of the two fans will be then given.

In the following experiments the air was measured as at Pleasley in the fan drift, as well as in the returns near the bottom of the upcast pit, the useful effects being based on the latter. The fan drift was divided into nine spaces by strings fastened at equal distances vertically and horizontally across the drift. The water-gauge was fixed parallel with the air current, the orifice being 8 feet from the fan inlet. The amount of air passing was measured with an anemometer in three different ways. First, the quantity obtained in the ordinary way in the returns near the pit bottom; second, by holding the anemometer one minute in each space in the fan drift, and then multiplying the average corrected reading obtained in the nine spaces by the total area of the drift; and third, by multiplying the area of each separate space in the drift, by the readings obtained in each, the quantities thus obtained in the nine spaces being added together. The following were the results, the water-gauge being 2·50 inches, and the revolutions of the fan 75 per minute in each :—

No. 1 method = 122,599 cubic feet per minute.
No. 2 „ = 125,364 „ „
No. 3 „ = 127,118 „ „

WADDLE FAN EXPERIMENTS, TEVERSAL COLLIERY, JUNE, 1891.

No. of Experiment.	Water-gauge in Fan Drift.	Water-gauge on Separation Doors in Pit.	Barometer on Surface.	Barometer in Pit.	Ther-mom'ter on Surface.	Ther-mom'ter near Bottom of Upcast Pit.	Revo-lutions of Fan per Minute.	Periphery Speed of Fan in feet per Second.	Cubic Feet of Air per Minute.	Indicated Horse-power of Engine.	Horse-power in the Air.	Useful Effect per Cent.	Lbs. of Coal per Indicated Horse-power of Engine per Hour.	Lbs. of Coal per Horse-power in the Air per Hour.	Steam Pr'sure per Square Inch. Boilers.	Cost of Fuel per Week at 3s. per Ton. £	s.	d.
1	1·65	1·50	28·88	30·01	49	73	60	94	102,421	49·8	26·6	53·4	9·0	16·8	46	5	0	9
2	1·95	1·70	28·88	30·01	49	70	65	101	103,381	66·2	31·7	47·8	8·4	17·6	50	6	6	0
3	2·15	1·90	28·87	30·00	50	70	70	109	114,309	78·8	38·7	49·1	8·7	17·3	42	7	10	4
4	2·50	2·00	28·85	29·99	51	70	75	117	122,599	94·3	48·2	51·1	9·2	18·1	53	9	16	6

Cost of oil, waste, etc., per week, fan at 70 revolutions per minute = 3s. 6d.

Natural ventilation measured when fan had been standing two hours, 23,000 cubic feet per minute.

Boilers.—All the boilers are on the surface, the steam being taken down the downcast pit for the hauling and pumping engines by 7-inch pipes. The following are the dimensions of the boilers :—

		Ft.	In.		Ft.	In.		Ft.	In.	
Nos. 1 to 7	Egg-ended boilers	40	0	×	5	0				
Nos. 8 „ 11	„ „	46	0	×	5	6				
Nos. 12 „ 15	Lancashire „	30	0	×	7	0	Tubes	2	6	diameter.
Nos. 16 and 17	„ „	30	0	×	6	0	„	2	5	„
Nos. 18 „ 19	Cornish „	29	0	×	6	0	„	3	1	„
Nos. 20 „ 21	Egg-ended „	36	0	×	4	7				
Nos. 22 „ 23	Lancashire „	30	0	×	7	0	„	2	7	„
No. 24	Egg-ended „	35	0	×	5	6				
Nos. 25 „ 26	„ „	36	0	×	5	0				

Nos. 22 and 23 are set on the Hyde and Bennett principle, the tops of the boilers being arched over with brickwork, and the gases from the flues allowed to circulate between the brickwork and the boiler plates. These two boilers have Proctor mechanical stokers applied to them, one with fixed bars and one with movable bars. The results obtained will be communicated when the members visit the collieries. Nos. 24, 25, and 26, are being set so as to be heated by the waste gases from the coke ovens. The pumps for these boilers are a donkey pump, with two 12-inch cylinders, 10-inch stroke, and 8-inch rams. A special, with 8-inch cylinder, 2-feet stroke, and 6-inch ram, and a donkey pump with two 8-inch cylinders, 8-inch stroke, and 6-inch rams.

Coke Ovens.—Twelve circular open-topped ovens, 17 feet 6 inches diameter, with perpendicular walls 7 feet 6 inches high and 18 inches thick, lined with fire-bricks. The tops are open the full area of the ovens. The main flue is built at the back of the ovens, 3 feet wide and 4 feet high, with straight fire-brick walls arched over the top. The small flues are arranged in the bottom of the ovens in the form of a cross, one arm running into the main flue, the draught being taken through three brick cones 18 inches high, with holes on each side, built on the flues in the bottom of the ovens. At the front of the ovens openings are left 4 feet 6 inches wide, and the full height for the doors. Instead of these being built with bricks, there are two folding doors to each oven of wrought iron, opening on hinges and fastening with an iron bar, the crevices being daubed and made air-tight.

The coke is made entirely from smooth hard, or cannel coal, which is loaded direct into the ovens by a temporary shoot from the trucks, in the same condition as it is picked off the belts, the large and small being as evenly mixed as possible. To ensure a proper draught a layer of large coal set on the edges is put in by hand at the bottom of each oven. The ovens are filled level with the tops, the coal being covered with fine ashes, and dust, 3 or 4 inches thick, in which six or seven openings are left for firing, the coal being lighted from the top. This covering has to be watched, so that the draught is kept as even as possible, and any opening that may occur is re-covered. The ovens are burnt from six to seven days, and at completion are watered by a spray placed on the top.

Oil.—Each oven makes about 100 gallons of crude oil per week, which accumulates in the bottom flues, and is run off each day through a 3-inch metal pipe, with a tap at the end. The oil is stored in a large cistern, and is used for the tub wheels instead of tram grease, more being produced than is required for the three collieries. Each oven is loaded with from 45 to 50 tons of coal, the yield of coke being from 58 to 60 per cent., and the cost of filling, drawing, and loading, 1s. 1d. per ton. The analysis of this coke is:—

Moisture	2·63
Carbonaceous matter	88·09
Sulphur	0·48
Ash	8·80
	100·00

Underground Haulage.—Two endless ropes are at work on the levels running in each direction from the pit bottom, the north level 1,250 yards in length, and the south level 1,700 yards, the former with best patent steel rope ¾-inch diameter (Lang patent), and the latter ¾-inch diameter of the same make. The ropes are worked by a horizontal condensing engine, with 30-inch cylinder and 5-feet stroke, geared, and with two driving wheels, each 6-feet diameter and 9-inches wide, fixed on an upright shaft, the respective ropes passing three times round each wheel. The steam pressure is 50 lbs. per square inch. This engine is placed in an engine house made underneath the engine plane on the north side of the pit, the ropes having a straight lead on to each level. The trams are brought to the pit bottom in sets of from twenty to thirty "tongues" or men with clips.

There are also two dip engine planes, the coals being brought up them on to the levels. The south dip is 160 yards from the shaft, worked by a pair of horizontal condensing engines with 22-inch cylinders and 3-feet 6-inches stroke, geared, and having a drum 7-feet diameter; steam pressure, 45 lbs. per square inch; dip of engine plane, 6 inches to the yard, sixteen trams being drawn each time. The north dip is at the extent of the north level, 1,100 yards from the shaft, and is worked by a pair of compressed air engines, with 20-inch cylinders and 3-feet 6-inches stroke, working direct on to a drum 4-feet 6-inches diameter. Ten trams are drawn up this incline each journey, the dip being from 6 to 9 inches to the yard. The air pressure varies from 40 lbs. at the beginning of the run to 26 lbs. per square inch at the end.

The air compressors are on the surface, and consist of two steam cylinders each 30-inches diameter with condensers, and two air cylinders each 38-inches diameter, with 6-feet stroke, and running from 16 to 24 strokes per minute; steam pressure at boilers 50 lbs., and air pressure at compressors 40 lbs. per square inch. The receivers are:—

	Ft.	In.		Ft.	In.
No. 1, at compressors	23	6	×	5	0
No. 2, „	28	0	×	7	0
No. 3, at hauling engines...	23	6	×	2	6
No. 4, at pump in dips	15	0	×	3	0
No. 5, „ „	10	0	×	3	0

The following are the results of diagrams taken from each steam and compressor cylinder:—

	Steam.	Air.
Indicated H.P., west side cylinders ...	201	163
„ east „ ...	195	167
Total	396	330

The ratio between horse-power in steam cylinders and horse-power in air cylinders being 83 per cent. The diagrams show that the indicated steam used averages 30 lbs. per square inch, of which 10 lbs. is due to vacuum. This could only be obtained where there was a constant stream of cold water accessible to condense with.

The compressed air is taken down the downcast pit in 11-inch pipes, and from the pit bottom to the air engines in-bye in 10-inch pipes. The distance from the compressors to the hauling engines is 1,400 yards. A pump is also worked by compressed air at the bottom of the north dips, a further distance of 800 yards, the air being taken this distance in 5-inch pipes. This pump has an 18-inch cylinder, with 14-inch stroke and 4-inch ram, and forces the water a height of 342 feet to the top of the dips, from whence it is conducted by a water-level to the pit bottom.

Underground Pumps.—Constant feeders of water, in addition to the above, flow from the old north rise workings near the outcrop of the coal, and from the upcast pit. The former is brought by the water-level to a cistern near the pit bottom, from which the level hauling engine obtains water for its condensers, the overflow from this cistern running into the standage. The water made in the upcast pit is conducted into another cistern, from which the condensers at the dips hauling engines are supplied, the overflow from this cistern also running into the standage. The feeders amount to about 220 gallons per minute, and to deal with these there is a Hathorne-Davey pump placed near the bottom of the upcast pit, with 32-inch cylinder, 6-feet stroke and 6-inch ram, working 10 strokes per minute, and forcing the water up a 6-inch rising main in the downcast pit to the reservoir on the surface. There is also a Tangye pump kept in reserve, and worked occasionally, with 30-inch cylinder, 4-feet 6-inches stroke and 8-inch ram, delivering up the same rising main as the Hathorne-Davey.

The general offices are at this colliery, and there is telephonic communication between these and the other pits.

The workshops have recently been rebuilt on the site of the old shops, and a storehouse and locomotive repairing shed erected.

The sidings having been constructed without the necessary fall for dealing with the traffic by gravitation it is necessary to keep three locomotives constantly at work for this colliery and Silver Hill. There is also a spare locomotive at Pleasley and Teversal Collieries ready for use.

The brickworks produce 30,000 hand-made bricks per week, and the perforated pan enables the ratchel to be ground and mixed with the clay and produce a good and serviceable brick.

The gas works, which have been enlarged, supply Teversal and Silver Hill Collieries and houses with gas.

The cottages, 280 in number, are nearly all at Stanton Hill, where there is a large school and workmen's club, and a resident curate paid by the company.

Silver Hill Colliery.

Winding Engines.—A pair of horizontal engines with 36-inch cylinders and 6-feet stroke, working a drum 20-feet diameter. Average piston speed when coal drawing, 384 feet per minute. The gearing is worked by a Melling patent steam driver, with 6-inch cylinder and 12-inch stroke.

There are two shafts, each 15-feet diameter, coals being at present drawn only at the downcast pit, which is fitted with rope conductors 1¼-inches diameter. It is intended when the Low Main workings become further developed, to draw coals at both shafts, and a new pair of winding engines will shortly be erected at the upcast pit for this purpose. The cages are double-decked, carrying two tubs on each deck, are made of iron, and weigh each 50 cwts. The winding ropes are 1¾-inches diameter of best patent steel, and have King detaching hooks.

Each shaft is lined with metal tubbing for a depth of 82 yards, commencing 24 yards from the surface. After heavy or long continued rains the water frequently runs over the top of this tubbing into the pits, in consequence of which a further length of 19 yards is being put into each shaft.

Boilers.—Steam is supplied to the winding, hauling, and belt engines from a range of nine Lancashire boilers of the following dimensions:—

Nos. 1 to 4, 30 feet by 7 feet, with tubes 2 feet 8 inches diameter.
No. 5 30 „ 7 „ „ 2 „ 6 „
No. 6 30 „ 7 „ „ 2 „ 8 „
No. 7 30 feet 6 inches by 7 feet, with tubes 2 feet 6 inches diameter.
Nos. 8 and 9, 30 feet 6 inches by 7 feet 6 inches, with tubes 3 feet diameter.

A Lancashire boiler, 30 feet by 8 feet, with tubes 3-feet 3-inches diameter, and set on the Hyde and Bennett principle, has been put down specially for the fan engines.

This boiler is made of ⅞-inch Siemens-Martin mild steel plates, the shell consisting of ten rings, each ring being one plate. The longitudinal seams are butt-jointed with cover straps inside and out, riveted with four rows of rivets, and the circular seams single riveted. All the rivet holes were drilled in position. The ends of the boiler are made of one plate ⅞-inch thick, the flue openings being bored out by machine. The boiler is designed for a working pressure of 100 lbs. to the square inch, and has been subjected to a hydraulic test of 175 lbs. The follow-

ing are the results of experiments made with this boiler with and without the cut-off on the valves of the fan engines :—

	Without Cut-off.	With Cut-off at $\frac{1}{16}$ of the Stroke.
Strokes of engine per minute	28	... 28
Duration of experiment in hours ...	6	... 6
Pressure in boiler in lbs. per square inch	70	... 70
Pounds of coals used per hour	765	... 392
Gallons of water evaporated per hour	510	... 238
Pounds of water evaporated per pound of coal	6·6	... 6·07
Tons of Top Hard slack used per week	57	... 29·4

The temperature of the feed-water was 50 degs. Fahr., the boiler being fed by an injector with steam from the same boiler.

Ventilation.—From the time this pit started in 1881 to the present year the ventilation has been produced by a small furnace with a grate surface of 10 feet by 5 feet. Through the depth of the shafts and large area of the wind-roads this furnace gave exceptionally good results, the consumption of coal being 30 tons per week or 3·6 cwt. per hour, and the average quantity of air 122,000 cubic feet per minute with 1·4 inches of water-gauge. According to figures recently obtained at Hetton Colliery, that furnace with a grate surface of 60 feet by 11 feet, using 1 ton of coal per hour, gave 300,000 cubic feet of air per minute with 2 inches of water-gauge.

Inasmuch as the Silkstone Seam is worked entirely with safety-lamps, and the whole of the return air comes in contact with the fire, and as there is 82 yards of tubbing in the shaft, which was gradually being eaten away by the smoke and heat, it was decided to put down a fan, and discontinue the use of the furnace. The fan is a double inlet Capell, 12-feet 6-inches diameter and 11-feet 6-inches wide, with inlets 7-feet 6-inches diameter. It is driven with ropes, the pulleys being 20 feet and 4-feet 6-inches diameter or 4·4 to 1. The pulleys and ropes were supplied by the Bowling Iron Company, who are also the makers of the fan. A pair of old winding engines with 26-inch cylinders and 5-feet stroke, which had not been in use for ten years were utilized for this purpose. These engines were fitted with drop valves, and the following table shows very conclusively how extravagant drop valves are, where continuous running is necessary, and where the cylinders are very much too large for the work they have to perform. Until the valves were carefully adjusted and the fan had worked into its bearings, it was impossible to keep the ropes on the driving pulley without having both engines at work, so as to preserve a uniform speed at each part of the stroke. This difficulty has been gradually overcome to a certain extent, and we are now able to drive the fan with one engine. Since the engines were erected the Worsley Mesnes Iron Works Company, of Wigan, have applied a cut-off motion, which has effected considerable economy. The following are the results of experiments made with this fan, with one engine, and both engines at work, also with and without the cut-off, and with four and six driving ropes:—

EXPERIMENTS WITH A CAPELL DOUBLE INLET FAN, SILVER HILL COLLIERY.

No. of Experiment.	Water-gauge in Fan Drift.	Water-gauge in the Pit.	Revolutions of Fan per Minute.	Strokes of Engine per Minute.	Cubic Feet of Air per Minute measured in the Returns in the Pit.	Horse-power in the Air.	Indicated Horse-power of Engines without Cut-off on Valves.	Useful Effect per Cent. without Cut-off.	Indicated Horse-power of Engine with Cut-off, and Six Driving Ropes on Pulleys.	Useful Effect per Cent. with Cut-off, and Six Driving Ropes on Pulleys.	Indicated Horse-power of Engine with Cut-off, and Four Driving Ropes on Pulleys.	Useful Effect per Cent. with Cut-off, and Four Driving Ropes.	Pounds of Coal per Hour per Indicated Horse-power without Cut-off, and One Cylinder.	Pounds of Coal per Hour per Indicated Horse-power with Cut-off, and One Cylinder.	Pressure of Steam at Boiler per Square Inch.
1	1·4	1·3	123	28	110,920	24·4	Two cylinders. 116·0	21·0	One cylinder. 53	46	One cylinder. 52·2	46·7	9·4	7·3	50
2	1·5	1·4	132	30	129,150	30·5	One cylinder. 86·8	35·0	64	47*	69·0	44·2	...	...	70
3	2·0	1·6	158	36	142,810	45·0	One cylinder. 127·0	35·2	96	46	95·5	47·0	...	...	72
4	2·9	2·3	185	42	169,710	77·5	No diagrams.	...	...	...	...	...	...	...	...
5	4·1	3·2	215	49	199,550	129·0	Two cylinders. 335·0	38·5	...	...	...	...	...	...	45

Cost per week for oil, waste, etc., fan running 128 revolutions per minute.

Furnace with 1·4 water-gauge gave 122,000 cubic feet per minute using 30 tons of coal per week.

* Fan ,, ,, 129,150 ,, ,, 82 ,, ,,

Natural ventilation after the fan had stood two hours, 34,000 cubic feet per minute.

Belts, etc.—There are two sorting belts, one for the black shale or Silkstone coal, and the other for Low Main, both being of similar construction to those already described at Teversal and Pleasley. The black shale belt is 75 feet long, and 4 feet wide. The coals are tipped on to a jigging screen, with a fall of 8 inches to the foot, by a side-revolving tippler. The nuts pass through a square mesh made of ⅜-inch steel wire, on to a cross belt 23 feet 6 inches long, running beneath the screen, where they are cleaned, and then delivered into the trucks. The nut slack passes through a square mesh into the trucks immediately below the screen. The jigging frame carrying the nuts and nut slack meshes is suspended by hangers, fixed to the sides of the screen; it is worked from eccentrics and makes 120 vibrations per minute. The best coals fall from the jigger on to the main belt, where they are cleaned and the cannel dressed off, the cleaned coals falling from this belt down a telescopic shoot into the trucks, the small made on the belt being taken out by a screen fixed in this shoot. This belt is driven by an engine with a 10-inch cylinder and 16-inch stroke, with gearing, and the jigger by another engine of the same size. The speed of the large belt is 54 feet per minute, and of the nut belt 58 feet per minute. Before this plant was erected the black shale coals were cleaned on nine ordinary screens with dead-plates at the foot of each. The cost has been reduced 2½d. per ton by the present system, the cost for banking, screening, sorting, and cleaning being now 4½d. per ton on a quantity of 300 tons per day. The selling price has also been greatly improved, as it was not possible to properly clean the coal by the old method.

Low Main Belts.—This is a similar arrangement to that described above, the belt being the same size. This screen is, however, a double jigging screen, each half being worked by a separate pair of eccentrics, fixed on the same shaft and making 200 vibrations per minute. The screen has a fall of 3 inches to the foot. The nuts pass through a square mesh, and the small through a mesh of smaller size. Owing to the inconvenient position of the sidings, it was found impossible to fix the nut shoot at such an angle as would permit the nuts to fall from this screen into the trucks. A back jigger was therefore put in, on to which the nuts fall and which throws them into the trucks, this jigger being worked from the same shaft as the others. The belt is driven by an engine with 10-inch cylinder and 16-inch stroke, and the jiggers by an 8-inch cylinder with 12-inch stroke. The speed of the belt is 72 feet per minute. The cost of banking, screening, and cleaning this coal is 2½d. per ton, the present quantity being 300 tons per day, part of which is drawn in the night shift. This cost will, of course, be considerably reduced when there is a greater quantity of coal drawn.

Coke Ovens.—There are 62 beehive ovens 12 feet in diameter and 7 feet high. The coke is made of black shale and Low Main small mixed in the proportion of one ton of the former to two of the latter. The black shale small is washed by a Robinson washer designed to wash 5 tons per hour, the washed coal falling down a draining shoot into a Devil disintegrator 4 feet 6 inches in diameter, capable of crushing 20

tons per hour, the Low Main small being brought at the same time from a large hopper into the disintegrator by a trough conveyor, the quantity being regulated to the proportion named. The crushed coal is raised by a bucket elevator into a large hopper, from which it is taken by pans in the ordinary way to the ovens. An engine with 10-inch cylinder, and 16-inch stroke, works the washer, and also two endless pan belts, one of these conveying the black shale coal into the washer, and the other the Low Main coal into the hopper, from which it is taken as described into the disintegrator, the latter being driven by belting by an engine with 18-inch cylinder and 3-feet stroke, which also works the bucket elevator. It is intended to add a revolving screen to this plant, for the purpose of taking out the peas or best of the small, and allowing only the smallest coal to go to the coke ovens; this will shortly be at work. The ovens are drawn twice a week, and are burnt alternately for three and four days each; the loads for three days are 98 cwt. of coal per oven, and for four days 112 cwt. The average yield of coke on the unwashed coal is 50 per cent., the cost for loading, drawing, and filling 1s. 4½d. per ton, and for washing and crushing 3d. per ton on the coke made.

Before the Robinson washer was erected the coal was washed in a pair of long wooden spouts or troughs, the water and coal being run in at the same time at the top of the trough. A series of wooden partitions or dams were made in the spouts, about 8 yards apart, over which the water flowed, carrying the coal forward to the hoppers, whilst the dirt and stones settled at the bottom of the spouts against each dam. This arrangement necessitated the use of large settling ponds, the overflow from which fouled the brook, and used nearly eight times the quantity of water required for the Robinson washer. The troughs are, however, kept in reserve and ready for work should any necessity arise.

The following is the analysis of Silver Hill coke :—

Moisture	0·70
Carbonaceous matter...	85·86
Sulphur	1·34
Ash	12·10
	100·00

A portable three-throw pump, each barrel 3 inches by 7 inches, to be driven by electricity, is being put in the Low Main Seam to pump the water out of the dip workings. The motor, with the pumps, will be fixed on a frame with wheels so arranged that the whole can be moved about the workings on the tram roads as desired. The motor will be covered with a special fire-proof casing and the pumps will be driven by means of a worm and worm-wheel connected to the motor shaft at a speed of 40 strokes per minute. The height of the pumps to the top of the air vessel above the rails will be 3 feet 3 inches, the length over all 5 feet 4 inches, and the width 3 feet. The dynamo will be fixed on the surface by the side

of the fan and will be driven by a rope from the large fan pulley. The cables from the dynamo to the motor will be taken down the upcast pit.

The pit bottom will be lighted with incandescent lamps and ultimately the screens also. If any satisfactory electric miner's lamp could have been perfected in time for the opening out of this pit it would have been adopted. A pair of 86-inch winding engines are being made, also wrought iron headstocks and belts and staging so as to draw Low Main coals at the upcast pit; this will necessitate the erection of a further lot of ovens and an independent washing and grinding plant.

Conclusion.

There is in connexion with the collieries a farm of 300 acres, the whole of which will be seeded down in the course of the next twelve months, and enough hay will be produced for all the horses. Two experimental ensilage stacks were made last year with Blunt automatic presses out of the second crop or aftermath, and were so satisfactory that this course will be adopted in future and thus prevent the necessity for buying sheep or cattle to graze during the winter.

The members of the Institution must bear in mind that these collieries are, some of them, twenty-five years old, and the newest is more than ten years old, and all the improvements that have been effected lately have been done without causing any of the pits to stand, and, naturally, there are many things which would have been different if the arrangements had all been made simultaneously, and within the last few years.

The following paper by Mr. T. M. Winstanley-Wallis on "The Low Tension System of Shot-firing" was taken as read:—

THE LOW TENSION SYSTEM OF SHOT-FIRING.

By T. M. Winstanley-Wallis, A.I.E.E.

In blasting operations, as carried on in mines, some form or other of firing by electricity is, in most districts, superseding the older methods of accomplishing the same end. The two principal systems of electric shot-firing are known respectively as the high and low tension; the former has been used in mining work to a large extent and for a very considerable time, while the latter is of comparatively recent introduction in the industry, though in cases where absolute certainty of firing is necessary, such as occur, for example, in the exploding of submarine mines, or stationary torpedoes, it has been usually employed.

It is to the latter system that the writer desires more especially to draw attention, but for purposes of comparison it will perhaps be advisable to describe briefly the component parts of both systems, and he will therefore begin with the high tension system as commonly in use.

Commencing with the fuze. This is usually constructed in the following manner:—Two pieces of copper wire are insulated from one another in a gutta-percha plug about $\frac{1}{2}$ inch long and $\frac{1}{4}$ inch diameter; these wires project slightly from one end of the plug, and this end is surrounded by a paper cylinder filled with priming. When a current of electricity is sent along the wires leading to the fuze, it has to jump across the space between the ends of the two wires, and the current producing a spark ignites the priming, and, in case of high explosives, the detonator which surrounds the cylinder. When the hole has been charged, the detonator inserted in the explosive, and properly tamped, the deputy connects the ends of the fuze wires projecting from the borehole by twisting to a length of twin cable, usually wound on a portable reel. He then retires to a safe distance, paying out the cable as he goes, and connects the other ends of the twin cable to the terminals of the battery, or magneto-exploder, by which the shot is to be fired.

The apparatus most generally in use is the latter. It is simply a small hand dynamo, which produces a current of electricity of high pressure, so that, when the handle is turned rapidly, and the connecting button on the instrument is pressed, the current passes along the cable and leaps across the gap, between the extreme ends of the wires in the fuze, in the form of a spark, thus firing the priming, and consequently the shot.

Passing now to the low tension system, this may be said to differ from the high tension, principally in the character of the current used.

In the high tension system a considerable pressure is required to spark across the gap between the wires in the fuze, but the volume of current is small, while the low tension current is of very low pressure, but the volume comparatively great.

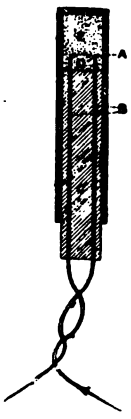


FIG. 1.
A—Platinum bridge
B—Copper wires.
C—Plug.
D—Priming composition.
E—Fulminate.

Beginning again at the fuze. In construction it is very similar to the high tension fuze already described, but instead of a space between the ends of the wires in the fuze they are connected by a bridge of fine platinum wire, which is surrounded by the priming; this bridge on being heated to a red heat by the firing current ignites the priming.

The method of connexion is essentially the same as that previously described; in place, however, of the magneto-exploder, the writer's firm, Messrs. John Davis & Son, of All Saints' Works, Derby, recommend the use of a small dry battery of special construction, which, for a small number of shots, is cheaper, lighter, and handier than a magneto-exploder; the latter can, however, be constructed to fire low tension fuzes, and where a large number have to be fired simultaneously the magneto-exploder may be found as convenient as a battery.

An extremely convenient method, and one far better than any portable means of firing low tension fuzes, is to work from the cables or wires of an electric light or power circuit, where such is within reach, treating the positive and negative cables as the poles of a battery: an arrangement used, the writer believes, by Mr. Frank Brain in the Forest of Dean.

A compact apparatus for firing single shots is also made, in which the reel of twin cable is mounted on a spindle projecting from the battery case; the whole can be slung over the shoulder by a strap, and the battery provides a pivot, on which the cable can be wound up, the whole weighing only 4¼ pounds, with 25 yards of twin cable. If the battery and the reel are used separately the battery can be carried in the pocket, and the reel either in another pocket or slung by a strap.

The only portion of the low tension system which has not been described is the testing apparatus. This is a sensitive galvanometer of special construction, combined with a dry battery. By means of this a small current can be passed through the fuze and galvanometer, deflecting the needle, and thus proving that the platinum wire bridge is intact; thus the deputy can test the fuzes before going down the pit and ensure that they are "alive;" by the same means the cable and battery can be tested, and the deputy will often be saved a long walk back from in-bye.

Turning now to a consideration of the relative advantages and disadvantages of the two systems, they have in common the advantage that, should a miss shot occur, there is no danger in at once approaching the hole, as is the case with ordinary fuze.

The advantages of the low tension over the high tension fuze may be summarized as follows:—

1.—Greater uniformity of construction, and therefore certainty of action. The points in the high tension fuze are liable to become displaced, either beyond sparking distance, or so close that they carry the current without sparking.

2.—Smaller, lighter, and cheaper means of firing. The one shot low tension battery measures 4¼ inches by 1¾ inches by 4¾ inches; it weighs 2 pounds, and its price is about a quarter that of the one shot magneto-exploder for high tension fuzes, which measures 5 inches by 4 inches by 4 inches, and weighs 4¼ pounds.

3.—Ease of testing fuzes, either before going down the pit, or after the hole has been tamped. High tension fuzes cannot be tested.

4.—High tension fuzes which have been kept for some time usually deteriorate greatly, while the low tension fuzes can be kept for any length of time without deterioration.

5.—Low tension fuzes can be fired from an electric light or power circuit; high tension fuzes cannot.

Finally, the writer can state as the result of considerable experience that high tension fuzes are far more productive of miss shots than low tension fuzes; the latter system, although only recently introduced for coal mining operations, is already largely adopted, and there is every reason to anticipate that it will ultimately displace the high tension system completely.

APPENDIX.

BAROMETER AND THERMOMETER READINGS FOR THE YEAR 1890.

By M. Walton Brown.

The barometer, thermometer, etc., readings have been supplied by permission of the authorities of the Glasgow and Kew Observatories, and give some idea of the variations of temperature and of atmospheric pressure in the intervening districts in which the mining operations of this country are chiefly carried on.

The barometer at Kew is 34 feet, and at Glasgow is 180 feet, above sea-level. The barometer readings at Glasgow have been reduced to 32 feet above sea-level, by the addition of ·150 inch to each reading, and the barometer readings at both observatories are reduced to 32 degs. Fahr.

The fatal explosions in collieries are obtained from the annual reports of H.M. Inspectors of Mines, and are printed upon the diagrams (Plates XLIV., XLV., XLVI., and XLVII.) recording the meteorological observations.

JANUARY, 1890.

KEW.								GLASGOW.							
	Barometer.				Temperature.				Barometer.				Temperature.		
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon
1	30·339	30·383	30·353	30·338	33·7	21·9	S	1	30·092	30·167	30·152	30·111	44·7	37·9	WSW
2	30·230	30·166	30·018	29·898	34·6	30·8	E	2	30·007	29·953	29·849	29·749	44·9	34·0	SW
3	29·761	29·723	29·630	29·599	36·2	31·8	SE	3	29·610	29·544	29·452	29·421	41·0	34·0	ESE
4	29·604	29·697	29·737	29·759	46·2	36·1	S	4	29·358	29·405	29·414	29·340	41·2	36·2	SW
5	29·721	29·721	29·793	29·930	51·3	43·9	SSW	5	29·058	29·094	29·216	29·371	48·7	40·4	SSW
6	30·124	30·227	30·233	30·329	53·3	49·3	SSW	6	29·624	29·847	29·732	29·782	50·8	38·0	SSE
7	30·341	30·347	30·331	30·347	53·8	47·7	SSW	7	29·678	29·748	29·885	29·954	52·0	39·6	SW
8	30·302	30·259	30·139	30·149	51·2	43·1	S	8	29·992	29·912	29·618	29·557	50·0	41·4	ESE
9	30·239	30·261	30·056	29·876	52·9	37·1	S	9	29·670	29·814	29·607	29·429	47·0	41·9	SW
10	29·893	30·002	30·059	30·191	53·1	40·3	W	10	29·400	29·628	29·920	30·015	47·0	37·8	NNW
11	30·219	30·215	30·120	30·077	51·1	38·9	SW	11	29·980	29·891	29·813	29·765	49·9	38·1	S
12	30·051	30·187	30·255	30·288	51·8	32·6	NW	12	29·753	30·003	30·034	29·845	51·1	41·5	WSW
13	30·169	30·104	30·075	30·169	51·8	34·2	SW	13	29·563	29·707	29·806	29·897	49·7	41·8	WSW
14	30·203	30·202	30·067	30·012	50·1	37·0	S	14	29·845	29·693	29·349	29·543	50·9	40·4	SSW
15	30·033	30·125	30·105	30·134	49·5	47·3	SW	15	29·779	29·860	29·752	29·729	49·0	39·1	SSW
16	30·112	30·133	30·095	30·105	52·2	45·9	SW	16	29·695	29·699	29·658	29·618	52·3	47·4	SSW
17	30·085	30·075	30·004	29·891	47·8	42·1	S	17	29·624	29·678	29·607	29·532	50·5	43·1	SSW
18	29·681	29·708	29·694	29·503	50·4	42·6	SW	18	29·224	29·180	29·023	28·739	48·9	38·4	SW
19	29·448	29·467	29·450	29·448	51·0	39·8	SW	19	28·699	28·671	28·838	28·925	44·8	34·6	SW
20	29·408	29·491	29·483	29·476	43·8	35·9	SW	20	28·990	29·072	29·097	29·146	38·3	32·6	SW
21	29·525	29·646	29·560	29·380	44·7	33·8	SW	21	29·167	29·171	29·003	28·925	40·2	34·2	SSW
22	29·044	29·085	29·276	29·191	43·9	38·4	W	22	28·713	28·803	28·913	28·916	40·5	33·1	WSW
23	28·842	28·651	28·962	29·430	49·2	35·5	WSW	23	28·797	28·827	29·003	29·156	36·8	28·9	WNW
24	29·596	29·733	29·748	29·651	50·5	34·7	SW	24	29·269	29·406	29·424	29·240	41·3	36·2	SSW
25	29·599	29·544	29·511	29·615	54·1	46·6	SSW	25	28·930	28·829	28·851	28·939	49·3	41·2	SW
26	29·710	29·885	29·828	29·694	50·6	40·2	WSW	26	29·033	29·287	29·271	29·319	43·8	37·3	WSW
27	29·650	29·867	29·986	30·057	51·3	40·1	W	27	29·367	29·549	29·750	29·879	41·2	34·9	W
28	29·928	29·668	29·673	29·828	49·2	36·4	SW	28	29·853	29·851	29·924	30·095	40·0	31·8	N
29	30·045	30·246	30·361	30·439	42·2	33·7	N	29	30·148	30·255	30·239	30·162	44·7	32·4	WSW
30	30·408	30·379	30·321	30·311	46·9	33·8	W	30	30·166	30·183	30·151	30·181	48·1	43·3	WSW
31	30·292	30·352	30·339	30·341	49·9	44·0	NW	31	30·162	30·197	30·229	30·211	50·7	45·0	WSW

FEBRUARY, 1890.

1	30·320	30·285	30·196	30·147	49·0	43·8	SW	1	30·087	29·989	29·858	29·815	47·2	41·5	SW
2	30·081	30·152	30·262	30·404	48·4	32·8	W	2	29·878	30·002	30·102	30·165	43·7	36·2	WSW
3	30·441	30·455	30·464	30·322	45·0	28·9	SW	3	30·201	30·230	30·182	30·130	46·2	43·7	WSW
4	30·241	30·176	30·073	30·050	39·1	28·2	W	4	30·027	30·021	30·028	30·099	45·2	36·4	WNW
5	30·026	30·080	30·112	30·179	43·9	36·1	N	5	30·136	30·193	30·187	30·223	44·0	31·9	WSW
6	30·175	30·239	30·235	30·292	41·0	34·8	NE	6	30·238	30·299	30·311	30·388	34·3	29·1	NNE
7	30·321	30·394	30·350	30·406	41·0	34·3	NE	7	30·433	30·480	30·457	30·459	38·4	29·9	NE
8	30·374	30·385	30·343	30·312	41·0	32·4	E	8	30·424	30·420	30·361	30·318	38·1	29·0	ENE
9	30·215	30·197	30·141	30·173	38·3	33·7	ENE	9	30·269	30·275	30·233	30·245	36·5	29·2	E
10	30·171	30·269	30·274	30·320	44·8	31·2	E	10	30·234	30·273	30·231	30·262	38·0	33·7	E
11	30·302	30·271	30·154	30·104	42·0	27·5	E	11	30·257	30·255	30·138	30·092	40·0	29·5	ENE
12	30·036	29·964	29·806	29·739	41·1	29·5	E	12	29·984	29·921	29·791	29·775	38·4	31·8	ESE
13	29·664	29·685	29·702	29·766	40·1	29·1	ESE	13	29·749	29·744	29·727	29·784	37·3	31·6	SE
14	29·803	29·856	29·838	29·813	41·1	36·5	N	14	29·812	29·850	29·838	29·860	35·4	32·8	ENE
15	29·627	29·458	29·380	29·520	39·8	33·2	NE	15	29·835	29·794	29·674	29·589	38·5	29·7	W
16	29·632	29·728	29·738	29·778	48·9	34·2	S	16	29·479	29·477	29·551	29·647	38·6	34·3	SW
17	29·736	29·811	29·860	29·968	49·8	38·3	SE	17	29·710	29·814	29·855	29·990	44·2	36·5	ESE
18	30·002	30·096	30·103	30·165	46·3	38·7	ENE	18	30·048	30·163	30·192	30·260	41·7	38·2	ENE
19	30·173	30·222	30·187	30·177	42·6	36·9	ENE	19	30·249	30·265	30·204	30·169	40·7	36·1	E
20	30·106	30·061	30·042	30·082	39·1	37·1	E	20	30·113	30·070	30·013	30·011	36·7	34·2	SSE
21	30·099	30·167	30·191	30·285	40·1	34·8	N	21	30·014	30·074	30·125	30·235	38·1	33·6	NNE
22	30·337	30·455	30·505	30·595	42·6	36·1	NE	22	30·304	30·425	30·478	30·564	43·1	36·0	W
23	30·623	30·656	30·613	30·648	41·9	31·9	NE	23	30·587	30·656	30·646	30·674	50·9	39·9	WNW
24	30·592	30·565	30·485	30·484	45·1	31·1	NE	24	30·621	30·636	30·603	30·620	48·0	37·2	SE
25	30·486	30·479	30·348	30·283	42·4	34·5	NNE	25	30·599	30·590	30·468	30·444	44·4	39·8	ESE
26	30·241	30·251	30·253	30·394	43·2	37·2	NE	26	30·388	30·446	30·548	30·633	43·4	33·4	ENE
27	30·407	30·413	30·325	30·331	39·3	31·3	N	27	30·590	30·530	30·492	30·530	39·0	31·2	N
28	30·353	30·398	30·312	30·260	38·4	28·1	N	28	30·498	30·447	30·279	30·119	38·5	29·0	WNW

MARCH, 1890.

KEW.								GLASGOW.							
	Barometer.				Tempera-ture.				Barometer.				Tempera-ture.		
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon
1	30·118	30·010	29·873	29·954	35·1	27·6	SW	1	29·987	30·069	30·112	30·218	40·0	30·9	ENE
2	30·058	30·173	30·223	30·321	33·1	23·8	NNE	2	30·277	30·369	30·408	30·487	37·2	28·9	E
3	30·356	30·469	30·421	30·464	31·9	22·4	NE	3	30·486	30·498	30·405	30·329	39·0	24·9	WSW
4	30·424	30·403	30·212	29·979	34·5	18·3	NSW	4	30·142	29·947	29·662	29·682	46·1	37·9	SW
5	29·800	29·872	29·879	29·848	44·3	34·1	N	5	9·749	29·815	29·661	29·585	47·2	37·3	WNW
6	29·761	29·762	29·766	29·818	54·3	39·2	WNW	6	29·476	29·580	29·592	29·444	49·0	42·9	WNW
7	29·788	29·780	29·702	29·634	52·4	40·7	W	7	29·437	29·394	29·173	29·310	47·5	36·7	WSW
8	29·584	29·540	29·383	29·375	51·8	40·5	SW	8	29·312	29·187	28·965	29·276	41·8	31·5	SSE
9	29·559	29·839	30·026	30·246	42·8	31·1	NW	9	29·512	29·765	29·898	29·829	38·9	28·7	NW
10	30·225	30·126	30·114	30·169	50·8	30·9	SW	10	29·645	29·693	29·686	29·695	52·2	35·9	WSW
11	30·175	30·247	30·263	30·342	55·7	44·4	W	11	29·691	29·756	29·879	29·964	52·3	47·9	WSW
12	30·324	30·322	30·235	30·194	56·5	36·6	W	12	29·933	29·893	29·859	29·787	50·1	48·0	SW
13	30·084	30·013	29·900	29·891	47·7	40·3	SW	13	29·663	29·567	29·572	29·639	50·0	40·5	W
14	29·820	29·806	29·746	29·741	55·0	39·7	SW	14	29·624	29·620	29·512	29·431	47·1	36·9	SSW
15	29·633	29·601	29·503	29·432	52·4	40·2	S	15	29·283	29·196	29·174	29·175	49·2	41·7	S
16	29·281	29·202	29·134	29·172	55·6	42·9	S	16	29·083	29·032	28·960	29·021	54·8	39·5	SE
17	29·253	29·370	29·417	29·495	52·0	35·6	W	17	29·077	29·179	29·233	29·300	46·0	36·0	WNW
18	29·469	29·442	29·327	29·326	52·1	32·0	E	18	29·300	29·374	29·422	29·546	48·1	38·7	S
19	29·357	29·431	29·464	29·457	43·2	40·0	N	19	29·630	29·669	29·667	29·702	47·6	37·5	NE
20	29·404	29·390	29·399	29·462	44·5	35·7	WNW	20	29·655	29·530	29·387	29·340	45·4	34·7	NNE
21	29·504	29·605	29·640	29·702	50·2	33·4	W	21	29·359	29·452	29·521	29·577	46·9	38·2	SW
22	29·721	29·745	29·729	29·750	52·9	35·3	SW	22	29·540	29·539	29·482	29·465	47·7	39·9	SW
23	29·697	29·654	29·551	29·627	50·0	42·9	S	23	29·467	29·493	29·493	29·517	49·4	37·9	WNW
24	29·633	29·495	29·201	29·147	48·8	36·3	S	24	29·411	29·291	29·128	29·069	48·0	35·4	SE
25	29·156	29·283	29·399	29·568	54·2	43·4	SW	25	29·043	29·195	29·335	29·383	45·0	41·3	ENE
26	29·676	29·761	29·872	30·010	58·2	40·6	W	26	29·299	29·393	29·555	29·677	50·4	42·2	W
27	29·993	30·025	30·041	30·067	55·0	49·4	SW	27	29·557	29·694	29·754	29·812	54·4	43·5	W
28	30·048	30·056	29·951	29·936	64·2	45·9	S	28	29·803	29·835	29·830	29·827	51·8	45·0	WNW
29	29·824	29·923	29·982	30·053	54·7	37·9	WSW	29	29·770	29·736	29·730	29·800	50·8	42·8	SW
30	30·069	30·095	30·054	30·117	56·9	32·0	WNW	30	29·866	29·988	30·031	30·134	49·0	38·3	W
31	30·155	30·218	30·232	30·283	50·5	35·1	NW	31	30·202	30·254	30·225	30·239	50·1	33·8	NE

APRIL, 1890.

1	30·302	30·351	30·254	30·247	47·7	35·0	NE	1	30·246	30·230	30·163	30·174	54·7	34·6	SW
2	30·196	30·130	30·061	30·079	46·9	32·2	E	2	30·144	30·117	30·025	30·062	59·0	37·7	NNE
3	30·073	30·099	30·067	30·117	51·4	35·9	NE	3	30·079	30·122	30·089	30·113	57·0	36·2	SW
4	30·091	30·117	30·044	30·111	56·1	32·8	NE	4	30·107	30·106	30·044	30·066	56·9	35·1	SW
5	30·090	30·090	30·004	29·999	56·3	30·8	N	5	30·040	30·060	29·961	29·866	54·0	40·8	SW
6	29·917	29·887	29·800	29·728	53·3	40·4	SW	6	29·730	29·684	29·576	29·382	52·2	43·8	WSW
7	29·619	29·456	29·456	29·626	54·7	41·3	W	7	29·208	29·299	29·477	29·572	52·0	38·2	NNW
8	29·641	29·629	29·633	29·763	50·2	37·8	NW	8	29·570	29·645	29·762	29·871	47·0	36·0	NNW
9	29·814	29·859	29·843	29·766	47·0	39·0	NNW	9	29·874	29·863	29·736	29·705	47·2	33·7	WNW
10	29·668	29·711	29·767	29·851	44·0	35·8	NE	10	29·777	29·811	29·798	29·875	47·0	34·4	NW
11	29·857	29·888	29·848	29·868	47·2	34·9	NNW	11	29·913	29·923	29·885	29·865	47·1	32·9	N
12	29·837	29·797	29·714	29·710	49·9	33·1	NW	12	29·800	29·745	29·683	29·694	44·0	35·5	ENE
13	29·658	29·628	29·544	29·548	51·7	37·9	E	13	29·666	29·629	29·547	29·578	46·1	32·0	ENE
14	29·498	29·455	29·392	29·397	54·9	40·9	E	14	29·573	29·597	29·567	29·599	48·2	34·1	SE
15	29·356	29·362	29·315	29·369	56·9	45·6	E	15	29·570	29·571	29·550	29·600	48·1	36·7	E
16	29·318	29·356	29·349	29·412	59·4	46·1	E	16	29·580	29·578	29·582	29·607	47·0	41·5	E
17	29·367	29·418	29·428	29·494	55·1	43·2	NE	17	29·610	29·651	29·697	29·764	46·7	40·8	E
18	29·509	29·564	29·628	29·745	46·2	42·1	NNE	18	29·800	29·852	29·886	29·955	47·2	39·9	E
19	29·784	29·865	29·909	30·019	45·3	39·9	NNE	19	29·952	29·972	29·976	30·004	45·0	39·1	ESE
20	30·072	30·153	30·150	30·194	53·2	39·3	WSW	20	30·004	30·016	29·987	29·962	49·2	39·2	S
21	30·183	30·160	30·106	30·062	56·4	42·9	SW	21	29·891	29·719	29·735	29·712	57·0	45·1	SSW
22	29·924	29·827	29·827	29·951	60·3	43·5	SW	22	29·378	29·442	29·529	29·600	51·8	42·0	W
23	29·971	29·980	29·977	29·905	56·6	41·6	WNW	23	29·599	29·649	29·683	29·658	52·4	41·7	W
24	29·674	29·613	29·587	29·543	53·6	44·7	WSW	24	29·583	29·504	29·430	29·388	50·4	39·2	W
25	29·341	29·242	29·343	29·472	49·5	40·3	NNE	25	29·320	29·318	29·304	29·392	52·0	36·8	W
26	29·516	29·573	29·677	29·785	53·3	34·0	NW	26	29·502	29·662	29·737	29·850	51·2	38·4	N
27	29·846	29·917	29·946	29·987	53·1	36·3	NNW	27	29·878	29·934	29·920	29·942	56·3	38·4	NW
28	29·947	29·939	29·857	29·896	56·9	40·1	SW	28	29·919	29·878	29·772	29·771	51·8	36·3	NW
29	29·901	29·894	29·867	29·915	59·1	40·5	S	29	29·767	29·775	29·749	29·788	55·3	37·2	SSW
30	29·915	29·944	29·912	29·929	62·7	40·2	E	30	29·802	29·876	29·872	29·909	60·0	46·4	S

MAY, 1890.

KEW.								GLASGOW.							
	Barometer.				Temperature.		Direction of wind at noon		Barometer.				Temperature.		Direction of wind at noon
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.		Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	
1	29·886	29·868	29·815	29·866	62·5	44·9	E	1	29·937	29·952	29·911	29·924	61·1	43·5	SE
2	29·859	29·881	29·855	29·889	61·3	41·1	E	2	29·849	29·865	29·722	29·781	59·9	41·9	SE
3	29·861	29·835	29·773	29·773	65·5	37·9	SSE	3	29·789	29·761	29·684	29·729	61·8	43·2	ENE
4	29·709	29·665	29·557	29·526	63·1	41·0	S	4	29·712	29·692	29·644	29·685	60·8	43·5	E
5	29·476	29·521	29·778	29·650	61·3	46·1	SW	5	29·669	29·653	29·611	29·633	59·9	48·1	ENE
6	29·646	29·659	29·602	29·632	62·1	43·0	SSE	6	29·611	29·622	29·586	29·601	58·0	47·6	ENE
7	29·606	29·602	29·572	29·593	61·3	40·1	ESE	7	29·585	29·616	29·602	29·671	58·1	44·8	E
8	29·576	29·595	29·585	29·639	60·0	42·3	NNE	8	29·670	29·724	29·718	29·759	54·0	44·8	ENE
9	29·602	29·545	29·423	29·402	51·2	47·0	NE	9	29·740	29·701	29·628	29·582	56·2	47·8	E
10	29·406	29·445	29·444	29·453	60·6	48·2	S	10	29·493	29·443	29·440	29·478	49·8	46·4	E
11	29·346	29·447	29·517	29·575	63·0	48·3	SW	11	29·493	29·519	29·440	29·425	53·9	46·8	ENE
12	29·548	29·544	29 493	29·504	64·1	46·0	N	12	29·405	29·449	29·436	29·487	60·8	47·0	SW
13	29·512	29·554	29·578	29·684	62·3	48·4	NW	13	29·500	29·529	29·481	29·454	57·8	45·0	W
14	29·695	29·833	29·900	30·026	61·3	47 0	W	14	29·489	29·565	29·645	29·708	56·0	42·5	SW
15	30·049	30·074	30·042	30·044	60·9	42·4	SW	15	29·733	29·746	29·743	29·786	57·0	42·5	SSW
16	29·965	29·887	29·773	29·685	66·9	43·1	S	16	29·753	29·735	29·657	29·530	53·6	46·8	SSW
17	29·626	29·679	29·712	29·713	61·9	46·2	SW	17	29·336	29·336	29·461	29·576	57·7	47·9	SW
18	29·689	29·705	29·724	29·736	62·4	48·5	SSE	18	29·597	29·633	29·662	29·717	58·6	47·0	SE
19	29·720	29·693	29·602	29·564	67·2	42·1	ESE	19	29·730	29·781	29·753	29·761	58·4	48·5	ENE
20	29·619	29·671	29·779	29·931	59·5	49·2	S	20	29·682	29·636	29·588	29·671	60·4	49·0	ENE
21	30·014	30·110	30·169	30·244	65·9	49·1	S	21	29·716	29·858	25·980	30·078	58·3	50·0	SSW
22	30·271	30·287	30·227	30·246	69·9	41·7	NE	22	30·143	30·222	30·236	30·247	61·8	52·3	SSW
23	30·210	30·173	30·103	30·092	68·0	46·6	E	23	30·240	30·206	30·140	30·177	70·0	47·9	ENE
24	30·047	29·999	29·941	29·940	73·4	50·9	E	24	30·196	30·177	30·120	30·116	66·6	48·7	E
25	29·888	29·860	29·813	29·921	72·6	51·2	NE	25	30·075	30·039	30·056	30·083	59·2	44·2	E
26	29·907	29·915	29·894	29·940	59·1	45·2	N	26	30·068	30·050	29·995	30·037	61·0	43·6	ENE
27	29·947	29 945	29·936	30·026	59·3	41·1	NE	27	30·023	30·030	29·999	30·040	61·1	44·4	NW
28	30·031	30·090	30·094	30·117	59·1	42·8	N	28	30·046	30·046	30·023	30 047	62·0	42·8	WSW
29	30·106	30·105	30·043	30·003	63·1	45·4	W	29	29·998	29·946	29·855	29·756	53·8	46·1	W
30	29·866	29·930	29·959	30·027	61·9	43·9	WSW	30	29·800	29·884	29·956	30·014	51·0	40·3	NW
31	30·115	30·138	30·114	30·110	57·2	39·3	NW	31	30·051	30·065	30·047	30·032	55·9	38·4	NW

JUNE, 1890.

1	30·082	30·054	29·946	29·931	63 0	38·3	W	1	29·929	29·821	29·734	29·752	56·1	43·8	SW
2	29·986	29·921	29·909	29·939	65·3	50·3	W	2	29·764	29·738	29·580	29·549	54·6	43·7	SW
3	29·929	29·951	29·899	29·881	62·1	50·3	SW	3	29·550	29·566	29 509	29·292	56·2	51·0	SW
4	29·825	29·833	29·825	29·861	59·1	53·5	S	4	29·469	29·594	29·638	29·683	62·5	51·7	WSW
5	29·907	29·967	29·979	30·007	65·2	53·4	SSW	5	29·686	29·715	29·753	29·708	62·6	52·7	SW
6	29·948	29·879	29·914	30·098	66·9	47·7	SW	6	29·619	29·678	29·880	30·083	57·4	42·3	WNW
7	30·180	30·277	30·290	30·325	63·9	46·2	NW	7	30·172	30·241	30·273	30·294	58·3	39·5	WNW
8	30·306	30·239	30·156	30·091	63·2	42·7	S	8	29·231	30·111	29·954	29·843	59·1	39·0	SE
9	30·039	30·041	29·998	29·985	68·8	50·0	SW	9	29·788	29·821	29·840	29·840	63·3	52·1	WSW
10	29·897	29·766	29·687	29·679	70·9	46·2	SSE	10	29·803	29·720	29·571	29·537	68·2	52·8	S
11	29·661	29·612	29·587	29·586	62·2	50·8	SW	11	29·511	29·496	29·502	29·577	56·3	51·2	ENE
12	29·537	29·590	29·671	29·791	65·0	50·5	N	12	29·606	29·689	29·848	30·000	57·7	51·7	NE
13	29·891	30·030	30·137	30·255	60·5	51·9	N	13	30·093	30·180	30·219	30·265	60·2	49·3	E
14	30·296	30·343	30·329	30·336	62·4	49·4	N	14	30·279	30·301	30·289	30·313	60·8	48·1	NE
15	30·354	30·371	30·317	30·302	69·6	49·6	NW	15	30·312	30·280	30·204	30·150	58·9	47·1	WNW
16	30·251	30·229	30·111	30·086	71·9	54·2	WSW	16	30·032	29·974	29·894	29·851	62·0	50·5	WSW
17	30·011	29·980	29·942	29·973	63·9	51·3	SW	17	29·760	29·734	29·733	29·828	59·5	49·0	WSW
18	30·015	30·080	30·037	30·019	65·9	47·7	SSW	18	29·878	29·885	29·803	29·861	59·0	47·4	WSW
19	30·037	30·106	30·113	30·116	68·3	54·2	NW	19	29·912	29·970	29·958	29·862	60·8	49·8	NW
20	30·070	30·056	30·019	30·049	67·6	50·6	WSW	20	29·770	29·818	29·871	29·923	61·3	50·8	W
21	30·052	30·083	30·058	30·124	69·3	49·7	NW	21	29·909	29·932	29·921	29·924	60·9	49·8	WSW
22	30·114	30·123	30·107	30·122	66·1	50·8	SW	22	29·910	29·954	29·984	30·017	61·5	52·1	WSW
23	30·114	30·141	30·141	30·148	69·2	57·4	W	23	30·037	30·040	30·018	30·042	60·7	51·0	WSW
24	30·149	30·156	30·109	30·100	75·0	58·1	SW	24	30·044	30·053	30·001	29·840	61·7	50·7	SW
25	30·072	30·083	30·037	30·031	75·7	54·6	WSW	25	29·733	29·850	29·933	29·966	60·1	46·5	W
26	29·967	29·907	29·847	29·831	67·9	54·0	SW	26	29·909	29·833	29·747	29·678	59·3	43·0	WSW
27	29·800	29·797	29·771	29·810	65·8	50·0	W	27	29·594	29·553	29·583	29·650	61·2	46·1	WNW
28	29·796	29·784	29·760	29·777	64·4	49·0	SSW	28	29·694	29·758	29·775	29·831	59·8	48·0	ENE
29	29·808	29·879	29·839	29·798	66·7	49·0	NW	29	29·807	29·754	29·654	29·514	61·6	46·9	WSW
30	29·585	29·300	29·147	29·175	64·4	50·9	S	30	29·314	29·206	29·191	29·315	55·8	51·4	ESE

JULY, 1890.

KEW.								GLASGOW.							
	Barometer.				Temperature.				Barometer.				Temperature.		
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon
1	29·174	29·277	29·388	29·564	65·2	49·7	W	1	29·417	29·559	29·630	29·701	63·1	51·4	NE
2	29·685	29·780	29·787	29·803	67·6	52·6	W	2	29·687	29·675	29·661	29·670	57·9	49·4	NNW
3	29·761	29·753	29·769	29·845	65·2	50·4	NW	3	29·651	29·705	29·719	29·742	58·8	48·7	E
4	29·845	29·812	29·722	29·618	62·3	46·9	SW	4	29·718	29·726	29·697	29·700	62·4	44·6	NW
5	29·481	29·478	29·592	29·703	58·7	50·2	N	5	29·712	29·706	29·691	29·754	61·5	47·7	NW
6	29·735	29·801	29·847	29·916	60·0	48·0	WNW	6	29·760	29·787	29·751	29·777	60·9	48·3	NW
7	29·924	29·921	29·868	29·742	63·6	47·6	SW	7	29·743	29·694	29·604	29·424	58·3	46·1	SW
8	29·518	29·501	29·576	29·722	68·8	52·5	SW	8	29·208	29·387	29·463	29·493	60·2	47·1	WNW
9	29·722	29·722	29·670	29·748	60·9	54·0	SSW	9	29·528	29·576	29·620	29·733	60·7	46·0	W
10	29·852	29·949	29·952	29·935	65·3	48·0	NW	10	29·818	29·883	29·896	29·912	59·0	44·0	NW
11	29·882	29·869	29·903	29·965	58·4	49·3	N	11	29·927	29·955	29·911	29·893	58·3	45·4	W
12	29·959	29·930	29·882	29·864	61·4	44·0	WSW	12	29·817	29·755	29·663	29·611	54·5	43·3	WSW
13	29·823	29·836	29·828	29·838	67·6	53·6	SW	13	29·550	29·451	29·423	29·371	66·8	51·7	SW
14	29·794	29·826	29·853	29·841	67·4	59·0	SSW	14	29·279	29·450	29·541	29·583	60·9	51·1	WSW
15	29·805	29·864	29·935	30·015	71·1	56·9	SW	15	29·594	29·656	29·761	29·896	64·2	49·5	WSW
16	30·055	30·072	30·024	30·020	73·9	50·4	W	16	29·978	30·044	30·032	30·058	66·6	46·5	SW
17	29·958	29·900	29·772	29·731	70·3	58·7	N	17	30·035	29·993	29·886	29·847	66·3	48·7	N
18	29·763	29·840	29·851	29·786	66·6	56·1	W	18	29·773	29·754	29·754	29·808	59 9	48·9	SW
19	29·691	29·830	29·984	30·134	62·3	50·4	N	19	29·891	30·012	30·045	30·140	67·9	52·1	NE
20	30·178	30·218	30·198	30·212	66·3	47·1	N	20	30·171	30·191	30·161	30·113	63·8	46·7	WNW
21	30·175	30·183	30·147	30·132	68·1	51·1	SW	21	30·056	30·053	29·998	29·922	65·5	54·8	WNW
22	30·068	30·061	30·028	30·081	71·9	57·8	W	22	29·928	29·925	29·928	29·949	61·7	51·8	W
23	30·106	30·138	30·075	30·036	74·2	54·1	W	23	29·955	29·857	29·849	29·801	62·9	52·5	W
24	29·932	29·934	29·929	29·988	72·3	55·0	W	24	29·804	29·844	29·869	29·898	60·9	50·9	W
25	30·021	30·066	30·065	30·070	69·0	51·3	W	25	29·914	29·953	29·938	29·887	63·3	49·5	W
26	30·028	30·025	29·998	29·992	68·7	57·0	SW	26	29·770	29·679	29·687	29·736	64·5	52·1	SW
27	29·970	29·956	29·902	29·884	68·1	56·3	SW	27	29·695	29·667	29·653	29·619	59·8	51·9	SW
28	29·832	29·837	29·855	29·930	70·3	53·4	NW	28	29·563	29·587	29·625	29·714	61·0	51·6	SW
29	29·965	29·996	29·978	29·977	68·5	48·3	SW	29	29·744	29·787	29·748	29·613	63·5	51·2	SW
30	29·935	29·922	29·902	29·933	66·9	55·1	SW	30	29·539	29·571	29·556	29·538	62·8	53·5	SW
31	29·922	29·949	29·943	29·967	68·9	61·8	SW	31	29·605	29·667	29·670	29·743	66·1	54·2	SW

AUGUST, 1890.

1	29·924	29·864	29·786	29·816	74·6	56·4	S	1	29·739	29·766	29·736	29·784	67·1	52·9	SW
2	29·869	29·927	29·971	30·062	66·2	51·9	NW	2	29·822	29·905	29·955	30·022	67·6	50·1	W
3	30·102	30·149	30·127	30·156	71·2	53·5	W	3	30·040	30·040	30·023	30·009	64·7	51·4	SW
4	30·165	30·201	30·182	30·211	73·2	55·3	WNW	4	29·990	30·009	30·018	30·035	65·9	57·8	SW
5	30·201	30·186	30·094	30·093	77·3	52·3	S	5	30·043	30·032	29·956	29·976	64·5	55·8	SW
6	30·083	30·085	30·057	30·089	74·3	53·8	WNW	6	30·028	30·059	30·088	30·117	62·0	51·2	WNW
7	30·105	30·150	30·114	30·138	69·6	56·3	ENE	7	30·127	30·140	30·115	30·143	66·2	55·2	NE
8	30·128	30·113	30·058	30·044	64·2	50·8	NE	8	30·155	30·159	30·106	30·134	68·0	53·7	ENE
9	30·012	29·996	29·937	29·900	66·7	56·9	NE	9	30·140	30·137	30·074	30·040	62·4	52·0	ENE
10	29·808	29·719	29·715	29·728	72·1	59·8	E	10	29·968	29·892	29·797	29·735	66·6	55·8	ENE
11	29·661	29·689	29·709	29·768	71·4	59·7	WSW	11	29·675	29·662	29·680	29·726	62·0	55·6	NE
12	29·746	29·753	29·751	29·752	67·9	56·7	W	12	29·718	29·700	29·684	29·703	64·1	52·8	WNW
13	29·740	29·742	29·689	29·720	66·5	53·6	WSW	13	29·697	29·722	29·671	29·641	63·9	51·6	NNE
14	29·727	29·757	29·744	29·724	65·3	52·1	WSW	14	29·592	29·566	29·519	29·427	61·6	51·7	SW
15	29·622	29·580	29·646	29·716	68·0	56·7	WSW	15	29·185	28·947	29·184	29·325	58·4	50·5	WSW
16	29·696	29·692	29·817	29·928	66·0	52·2	SW	16	29·370	29·415	29·484	29·527	59·7	48·0	WSW
17	29·927	29·933	29·881	29·890	69·	49·2	SW	17	29·503	29·595	29·654	29·747	61·4	49·0	W
18	29·837	29·830	29·783	29·773	68·7	52·4	W	18	29·761	29·802	29·804	29·842	61·6	48·0	WSW
19	29·720	29·804	29·826	29·842	58·7	54·4	NE	19	29·846	29·850	29·802	29·816	62·4	48·0	N
20	29·820	29·865	29·894	29·988	67·2	55·8	NW	20	...	29·708	...	29·787	63·2	47·5	SW
21	30·005	30·015	29·971	29·947	64·7	56·0	SW	21	29·738	29·705	29·643	29·721	59·3	47·9	WSW
22	29·987	30·066	30·042	29·976	65·9	52·2	W	22	29·716	29·742	29·743	29·633	57·9	48·6	WSW
23	29·762	29·654	29·695	29·734	66·1	50·3	W	23	29·508	29·515	29·521	29·573	58·0	45·6	WSW
24	29·699	29·674	29·646	29·649	64·0	44·5	SW	24	29·569	29·548	29·510	29·505	58·3	43·0	W
25	29·642	29·642	29·606	29·500	63·3	43·5	WSW	25	29·455	29·457	29·360	29·266	60·3	46·4	WNW
26	29·453	29·478	29·449	29·385	61·5	48·7	SW	26	29·186	29·160	29·161	29·170	55·1	44·3	W
27	29·403	29·398	29·377	29·511	62·4	49·8	SW	27	29·144	29·181	29·273	29·443	58·7	43·2	NE
28	29·604	29·734	29·779	29·865	64·9	48·6	NW	28	29·570	29·709	29·766	29·835	59·0	43·5	NW
29	29·889	29·936	29·908	29·958	61·5	47·2	N	29	29·840	29·875	29·914	30·000	58·1	42·9	N
30	29·968	30·026	30·032	30·088	59·8	41·7	N	30	30·028	30·069	30·052	30·095	56·8	44·0	N
31	30·099	30·165	30·202	30·277	59·5	40·5	N	31	30·135	30·178	30·170	30·183	57·4	40·9	WNW

SEPTEMBER, 1890.

KEW.								GLASGOW.							
	Barometer.				Temperature.		Direction of wind at noon		Barometer.				Temperature.		Direction of wind at noon
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.		Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	
1	30·294	30·309	30·252	30·267	63·3	36·9	SSW	1	30·133	30·052	29·979	29·956	56·2	45·9	SW
2	30·237	30·233	30·210	30·211	64·2	49·2	SW	2	29·921	29·942	29·964	29·987	61·9	55·2	WSW
3	30·203	30·217	30·191	30·218	66·0	52·4	SW	3	29·942	29·969	30·000	30·026	63·7	55·9	WSW
4	30·229	30·282	30·279	30·315	69·4	55·0	W	4	30·041	30·106	30·160	30·235	66·0	54·5	SW
5	30·320	30·340	30·295	30·325	72·4	53·2	NW	5	30·245	30·264	30·221	30·237	64·4	53·2	WSW
6	30·322	30·369	30·338	30·397	71·8	52·8	NW	6	30·284	30·368	30·363	30·384	63·9	50·8	W
7	30·407	30·454	30·417	30·441	68·2	50·0	E	7	30·380	30·393	30·335	30·346	68·1	46·7	SW
8	30·413	30·432	30·360	30·358	71·6	45·0	SE	8	30·313	30·283	30·206	30·163	68·2	52·7	SSW
9	30·328	30·335	30·237	30·226	72·1	46·8	SW	9	30·129	30·166	30·186	30·194	63·7	46·5	W
10	30·167	30·171	30·099	30·142	72·4	49·0	SW	10	30·148	30·124	30·048	30·038	59·1	45·2	WSW
11	30·142	30·155	30·137	30·215	69·7	50·9	W	11	29·929	30·039	30·114	30·182	60·2	50·8	WNW
12	30·224	30·257	30·213	30·225	68·3	47·0	NNW	12	30·181	30·208	30·194	30·200	61·8	51·4	WSW
13	30·203	30·226	30·187	30·221	68·0	46·0	W	13	30·161	30·156	30·079	30·107	66·5	45·9	NE
14	30·207	30·235	30·166	30·167	69·1	45·3	SE	14	30·108	30·145	30·090	30·091	66·9	52·2	SW
15	30·110	30·074	30·005	30·016	72·1	49·6	SE	15	30·030	29·964	29·861	29·879	67·3	51·2	SSE
16	29·981	29·978	29·917	29·917	73·1	45·8	SE	16	29·879	29·876	29·825	29·790	67·5	54·5	S
17	29·865	29·891	29·856	29·853	72·2	52·2	SE	17	29·757	29·799	29·781	29·764	63·9	56·5	S
18	29·829	29·884	29·898	29·931	67·8	56·2	S	18	29·698	29·736	29·806	29·861	62·6	52·8	WSW
19	29·901	29·891	29·840	29·765	66·3	52·2	S	19	29·814	29·797	29·723	29·706	63·4	47·9	ENE
20	29·598	29·614	29·660	29·699	65·8	55·0	S	20	29·607	29·477	29·418	29·441	61·0	50·0	SE
21	29·695	29·702	29·640	29·567	65·3	52·0	S	21	29·400	29·418	29·405	29·407	59·2	51·5	S
22	29·618	29·700	29·756	29·806	64·5	54·0	SSW	22	29·379	29·396	29·508	29·634	60·5	52·5	W
23	29·826	29·893	29·930	30·032	63·3	50·5	S	23	29·728	29·780	29·789	29·802	59·1	51·5	WNW
24	30·105	30·187	30·215	30·257	62·4	49·3	SW	24	29·778	29·805	29·870	30·018	59·4	48·8	WSW
25	30·271	30·352	30·395	30·455	64·4	50·1	WNW	25	30·133	30·220	30·203	30·048	57·5	47·2	WSW
26	30·410	30·415	30·393	30·430	66·7	49·3	WSW	26	29·992	30·051	30·163	30·218	60·7	56·2	WSW
27	30·422	30·422	30·326	30·317	72·6	56·0	W	27	30·171	30·138	30·111	30·075	60·1	56·7	WSW
28	30·223	30·215	30·112	30·122	70·1	54·7	SW	28	29·967	30·022	29·953	29·909	58·4	51·6	W
29	30·086	30·082	29·979	29·979	61·6	53·0	SW	29	29·802	29·715	29·530	29·634	54·4	48·0	SW
30	29·960	29·961	29·882	29·859	66·1	56·1	SW	30	29·646	29·579	29·373	29·300	57·6	46·0	NE

OCTOBER, 1890.

1	29·774	29·739	29·712	29·922	62·5	49·2	SW	1	29·243	29·370	29·585	29·912	54·4	42·2	W
2	30·136	30·315	30·354	30·375	58·7	41·6	W	2	30·092	30·208	30·140	29·989	52·9	39·1	WSW
3	30·324	30·299	30·213	30·232	64·3	43·5	SW	3	29·832	29·835	29·831	29·864	58·2	52·9	SW
4	30·195	30·196	30·157	30·190	66·2	49·2	W	4	29·896	29·948	29·940	29·932	57·9	53·8	SW
5	30·172	30·181	30·129	30·117	63·3	50·6	W	5	29·878	29·875	29·782	29·692	59·4	52·9	SW
6	30·060	30·065	30·032	30·048	64·4	53·1	W	6	29·733	29·803	29·830	29·857	55·5	49·5	WSW
7	30·015	30·002	29·904	29·997	60·9	53·2	SW	7	29·823	29·843	29·930	30·140	55·1	44·0	NW
8	30·185	30·342	30·380	30·457	58·9	44·2	NE	8	30·300	30·414	30·378	30·385	54·8	37·9	SE
9	30·440	30·461	30·371	30·378	58·7	36·4	SE	9	30·300	30·253	30·200	30·188	55·0	42·0	WSW
10	30·348	30·354	30·299	30·331	61·0	34·0	SW	10	30·138	30·162	30·138	30·121	58·9	53·8	SW
11	30·317	30·351	30·314	30·366	64·6	38·4	SW	11	30·103	30·135	30·159	30·217	58·2	54·3	SW
12	30·378	30·406	30·360	30·382	63·9	37·9	SW	12	30·209	30·230	30·200	30·213	58·8	50·0	SW
13	30·373	30·379	30·297	30·290	63·0	34·4	SW	13	30·196	30·194	30·143	30·076	54·7	49·8	SW
14	30·216	30·170	30·034	30·003	62·4	35·1	SW	14	29·974	29·912	29·844	29·671	57·3	49·0	SW
15	29·883	29·733	29·599	29·582	56·1	43·0	SW	15	29·374	29·395	29·310	29·211	51·2	40·7	WSW
16	29·563	29·642	29·664	29·684	54·0	52·1	W	16	29·333	29·385	29·436	29·651	49·7	42·9	WNW
17	29·797	29·839	29·864	29·879	54·0	44·8	WNW	17	29·687	29·770	29·814	29·919	51·1	43·9	WNW
18	29·908	29·987	30·023	30·089	53·1	44·0	NW	18	30·024	30·123	30·148	30·205	51·4	38·5	N
19	30·112	30·171	30·173	30·212	50·1	44·6	NNW	19	30·210	30·238	30·229	30·267	49·9	34·7	W
20	30·216	30·250	30·230	30·227	51·5	45·1	N	20	30·199	30·186	30·127	30·180	54·0	39·8	NNE
21	30·187	30·266	30·300	30·385	50·6	39·3	NW	21	30·177	30·241	30·273	30·336	56·2	48·6	WNW
22	30·424	30·509	30·485	30·512	53·1	38·9	SE	22	30·367	30·413	30·406	30·430	55·3	46·7	WNW
23	30·479	30·462	30·391	30·357	54·0	41·7	NW	23	30·385	30·363	30·250	30·142	53·4	51·0	WSW
24	30·279	30·210	30·093	30·005	56·2	49·1	WSW	24	29·976	29·866	29·775	29·774	53·2	45·5	WSW
25	29·823	29·714	29·524	29·548	55·2	43·7	SW	25	29·672	29·555	29·412	29·329	47·6	37·7	W
26	29·476	29·390	29·393	29·612	45·3	35·5	WNW	26	29·299	29·432	29·585	29·763	42·8	33·0	NW
27	29·749	29·877	29·908	29·980	42·9	30·2	NW	27	29·828	29·889	29·877	29·956	40·9	30·0	NW
28	30·013	30·101	30·095	30·097	42·7	25·5	WNW	28	29·956	29·967	29·772	29·633	52·0	29·4	SSW
29	30·004	29·972	29·855	29·813	56·8	36·4	WSW	29	29·514	29·431	29·471	29·651	54·6	44·5	WSW
30	29·851	29·929	29·942	29·934	58·0	42·8	N	30	29·801	29·880	29·835	29·668	48·6	39·0	W
31	29·800	29·651	29·477	29·478	55·9	43·8	SSW	31	29·430	29·348	29·326	29·490	50·4	44·9	WNW

NOVEMBER, 1890.

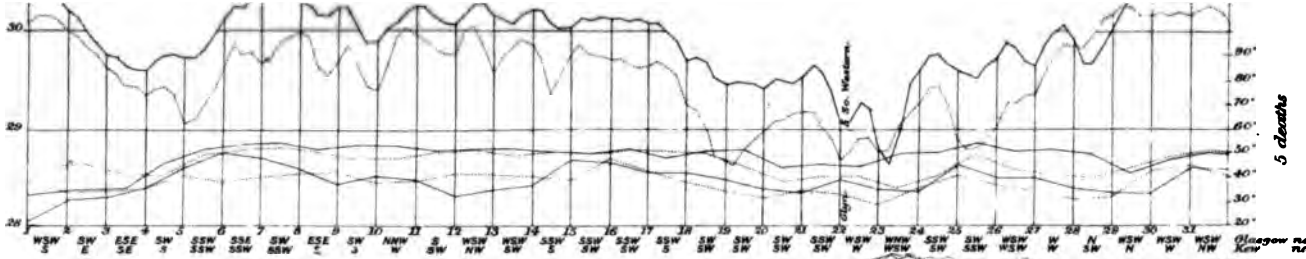
KEW.								GLASGOW.							
	Barometer.				Temperature.		Direction of wind at noon		Barometer.				Temperature.		Direction of wind at noon
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.		Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	
1	29·563	29·719	29·754	29·723	54·1	41·6	NW	1	29·590	29·647	29·556	29·230	51·2	42·0	W
2	29·442	29·302	29·242	29·364	55·6	41·6	WSW	2	28·837	28·904	29·002	29·285	52·6	40·0	W
3	29·560	29·655	29·544	29·381	49·2	39·0	SW	3	29·426	29·424	29·244	29·150	43·6	36·3	S
4	29·344	29·273	29·195	29·221	52·3	38·9	W	4	29·084	29·090	29·159	29·346	46·6	38·2	ESE
5	29·365	29·534	29·625	29·718	49·1	40·9	NNW	5	29·509	29·600	29·678	29·727	48·5	39·0	NNW
6	29·708	29·795	29·598	29·160	50·0	36·3	SW	6	29·663	29·509	29·065	28·635	46·2	40·0	S
7	28·997	29·169	29·286	29·465	49·5	42·5	W	7	28·723	29·109	29·364	29·462	47·2	36·2	NW
8	29·596	29·618	29·485	29·332	51·9	36·6	SSW	8	29·361	29·287	29·221	29·241	48·5	36·0	SSW
9	29·305	29·427	29·495	29·569	49·3	30·2	W	9	29·268	29·334	29·318	29·322	44·0	38·6	NW
10	29·602	29·677	29·650	29·609	43·2	31·4	W	10	29·477	29·536	29·433	29·441	43·4	35·8	E
11	29·476	29·394	29·528	29·656	49·9	34·0	SW	11	29·283	29·205	29·303	29·440	44·3	37·2	SE
12	29·742	29·845	29·854	29·856	50·6	29·1	SW	12	29·499	29·560	29·482	29·436	47·0	36·7	ENE
13	29·796	29·880	29·904	29·953	50·0	35·6	S	13	29·559	29·648	29·745	29·854	47·8	40·5	SW
14	29·999	30·019	29·978	29·961	56·1	35·8	S	14	29·848	29·778	29·507	29·571	53·7	38·6	SE
15	29·984	30·160	30·252	30·291	55·9	47·2	N	15	29·902	30·080	30·145	30·197	49·7	41·1	SW
16	30·254	30·257	30·197	30·258	54·8	47·0	S	16	30·144	30·044	29·974	30·122	44·3	36·6	E
17	30·318	30·378	30·370	30·396	52·5	40·2	W	17	30·199	30·220	30·159	30·075	50·8	37·0	NE
18	30·371	30·395	30·387	30·408	54·4	46·1	SW	18	30·094	30·213	30·243	30·236	51·6	45·3	NW
19	30·407	30·446	30·433	30·450	55·1	51·5	WSW	19	30·178	30·180	30·190	30·266	54·8	43·6	SW
20	30·436	30·473	30·436	30·396	55·1	50·1	W	20	30·258	30·263	30·159	30·070	53·3	44·6	SW
21	30·308	30·202	30·022	30·100	53·2	43·3	SW	21	29·904	29·808	29·901	29·861	51·6	40·4	WNW
22	30·123	30·149	30·036	29·805	50·7	41·0	WSW	22	29·799	29·797	29·489	29·399	51·3	41·4	WsW
23	29·647	29·580	29·443	29·354	58·3	49·8	W	23	29·370	29·311	29·169	29·119	50·3	39·5	WSW
24	29·168	29·278	29·517	29·618	55·0	35·2	NNW	24	29·203	29·431	29·490	29·550	41·2	34·5	WNW
25	29·620	29·709	29·778	29·941	41·7	31·4	N	25	29·615	29·877	30·088	30·192	41·4	34·8	ENE
26	30·029	30·109	30·098	30·088	34·1	25·5	NE	26	30·226	30·294	30·270	30·251	36·5	30·0	ENE
27	30·035	29·952	29·903	29·907	31·0	23·2	N	27	30·212	30·194	30·157	30·182	32·3	23·4	W
28	29·911	29·976	30·015	30·092	25·5	21·5	NE	28	30·177	30·207	30·165	30·181	36·1	25·8	NW
29	30·098	30·134	30·168	30·251	33·1	21·6	N	29	30·148	30·143	30·068	30·005	37·4	31·0	ENE
30	30·310	30·375	30·353	30·355	37·2	21·5	N	30	29·911	29·866	29·819	29·846	47·2	37·4	SW

DECEMBER, 1890.

1	30·251	30·179	29·999	29·900	39·9	25·5	S	1	29·805	29·790	29·752	29·745	51·8	48·0	SW
2	29·771	29·775	29·747	29·770	35·8	30·3	E	2	29·705	29·715	29·657	29·686	49·4	44·3	WNW
3	29·716	29·704	29·690	29·747	38·6	34·4	ESE	3	29·712	29·802	29·873	30·017	44·2	36·5	NE
4	29·687	29·682	29·683	29·760	43·8	36·1	NE	4	30·005	30·016	29·980	29·970	41·0	35·9	NE
5	29·786	29·815	29·811	29·859	40·7	35·5	ENE	5	29·943	29·963	29·984	30·043	40·2	37·6	E
6	29·877	29·969	30·013	30·072	39·1	36·0	E	6	30·087	30·142	30·150	30·203	40·0	35·5	ENE
7	30·092	30·117	30·064	30·043	38·8	33·9	E	7	30·196	30·186	30·130	30·120	40·0	34·0	E
8	29·973	29·939	29·911	29·934	35·4	31·1	E	8	30·088	30·062	29·978	29·949	40·2	34·1	ENE
9	29·957	30·049	30·039	30·085	36·9	28·8	NNE	9	29·916	29·999	30·017	30·083	40·1	32·4	SE
10	30·115	30·190	30·172	30·205	32·2	28·7	NNE	10	30·113	30·149	30·105	30·069	39·1	32·6	E
11	30·182	30·173	30·107	30·094	33·1	24·3	NNE	11	30·019	30·007	29·986	30·011	40·2	36·1	NE
12	30·085	30·128	30·111	30·124	32·8	22·9	E	12	30·025	30·078	30·080	30·064	38·1	33·5	ENE
13	30·088	30·086	30·023	30·022	28·2	16·4	NE	13	29·992	29·958	29·894	29·906	34·1	28·4	ENE
14	30·010	30·050	30·009	29·985	21·5	16·7	NE	14	29·927	29·951	29·889	29·803	40·6	30·7	SSW
15	29·865	29·735	29·653	29·724	31·2	21·2	NE	15	29·774	29·730	29·723	29·854	43·2	35·1	NE
16	29·767	29·764	29·752	29·758	31·2	24·4	E	16	29·859	29·895	29·894	29·910	38·1	35·0	E
17	29·781	29·864	29·894	29·938	32·0	24·4	N	17	29·914	29·957	29·946	29·908	38·2	32·2	SE
18	29·888	29·854	29·681	29·488	30·9	25·1	NE	18	29·802	29·682	29·514	29·357	33·6	28·7	SSE
19	29·240	29·217	29·354	29·541	29·5	25·0	E	19	29·251	29·257	29·337	29·495	30·9	27·3	ENE
20	29·651	29·800	29·878	30·061	33·7	15·5	NNE	20	29·637	29·772	29·884	30·041	35·6	29·2	SW
21	30·117	30·271	30·209	30·349	36·2	27·2	NE	21	30·179	30·273	30·293	30·279	32·1	24·3	WSW
22	30·340	30·337	30·241	30·154	27·1	10·8	NE	22	30·182	30·104	29·950	29·834	37·9	24·3	SSE
23	30·038	30·012	30·069	30·129	32·1	17·8	ENE	23	29·729	29·763	29·893	30·073	43·9	35·0	SW
24	30·242	30·346	30·329	30·362	32·1	24·0	E	24	30·185	30·270	30·237	30·216	35·3	27·0	NE
25	30·311	30·322	30·248	30·278	29·2	21·2	ESE	25	30·120	30·059	30·061	30·226	40·0	32·1	SW
26	30·288	30·324	30·314	30·302	34·0	24·8	ESE	26	30·340	30·434	30·436	30·440	38·8	33·2	NE
27	30·306	30·301	30·192	30·188	33·2	29·8	NNE	27	30·383	30·371	30·310	30·292	36·4	34·5	ENE
28	30·180	30·172	30·164	30·182	32·9	25·9	NE	28	30·246	30·248	30·226	30·266	35·7	33·7	ENE
29	30·207	30·227	30·175	30·180	32·8	26·2	NE	29	30·313	30·380	30·376	30·397	35·3	29·9	SW
30	30·171	30·245	30·201	30·181	28·2	20·7	NE	30	30·441	30·510	30·493	30·455	36·5	34·7	ENE
31	30·165	30·150	30·075	30·101	33·2	20·8	NE	31	30·348	30·305	30·260	30·198	37·5	35·7	E

1890.

JANUARY.



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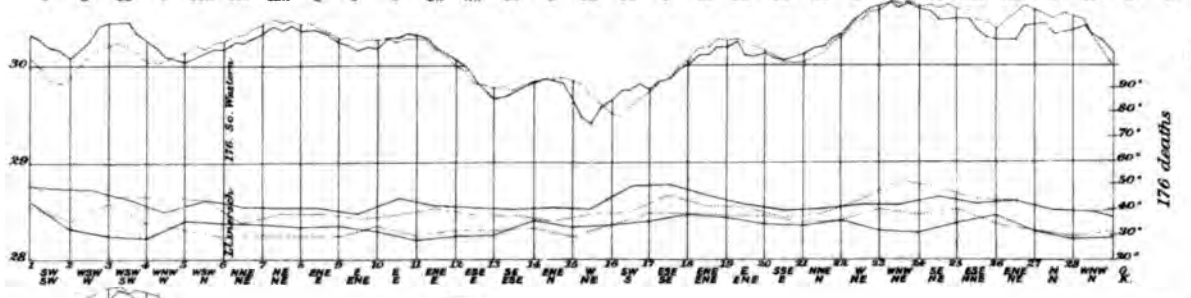

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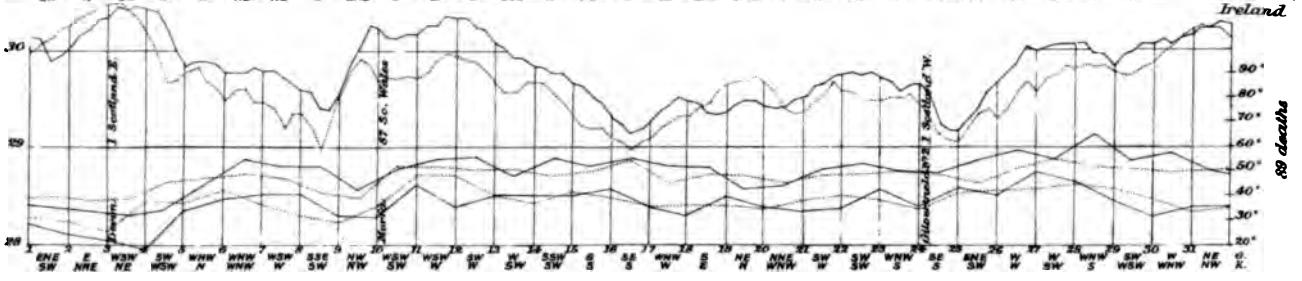


DEATHS FROM EXPLOSIONS OF FIRE DAMP DURING THE YEAR 1890. IN THE SEVERAL INSPECTION DISTRICTS.

Newcastle	0 Deaths
Durham	0 .
Manchester	2 .
Liverpool	1 .
Yorkshire	2 .
Midland	0 .
Staffordshire, North	2 .
Staffordshire, South	0 .
South-Western	182 .
South Wales	82 .
Scotland, East	5 .
Scotland, West	5 .
Ireland	0 .
Total	290

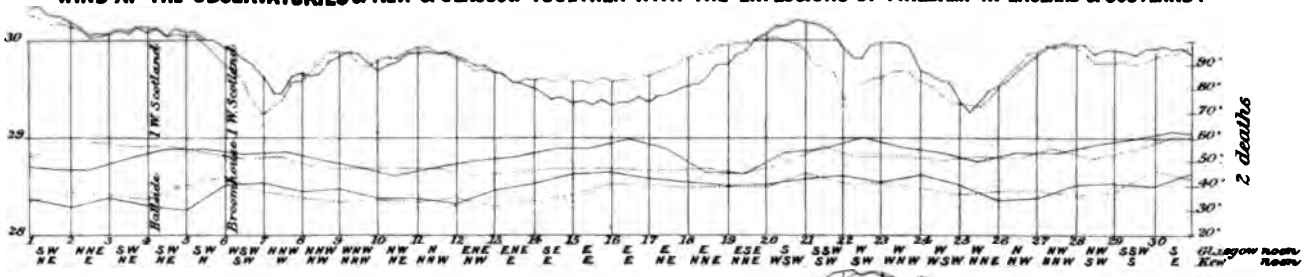
The firm top line is the Barometer reading at Kew taken 4 a.m. 10 a.m. 4 p.m. & 10 p.m.
The dotted top line is the Barometer reading at Glasgow taken do do. do. do.
The lower lines are the Maxima and Minima temperatures at Kew & Glasgow observed respectively at 10 a.m. & 10 p.m.
Kew lines are firm Glasgow lines are dotted
The figures attached to the districts show the Number of deaths caused by the explosions.

Transactions 1890-91

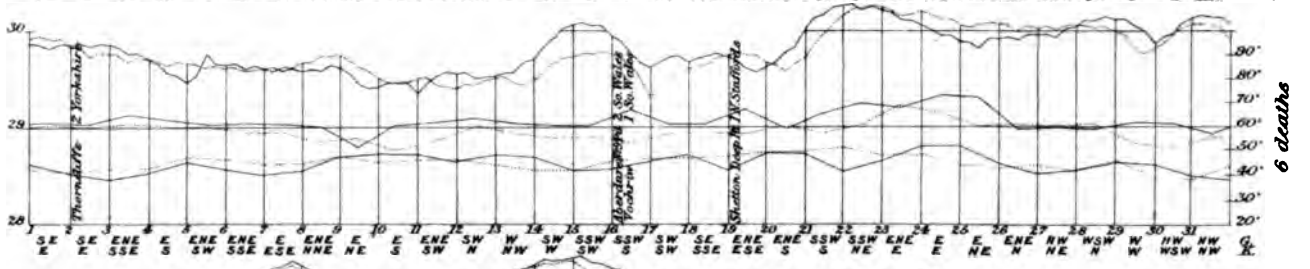
DIAGRAM SHEWING THE HEIGHT OF THE BAROMETER, THE MAXIMA & MINIMA TEMPERATURES & THE DIRECTION OF THE WIND AT THE OBSERVATORIES of KEW & GLASGOW TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND.

1890

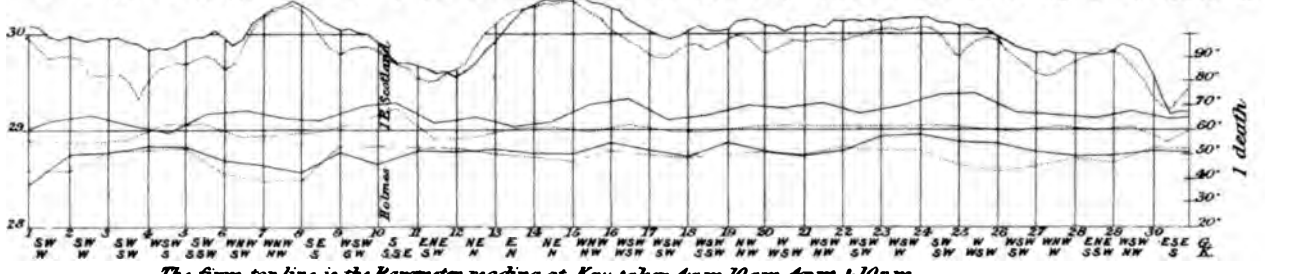
APRIL.



MAY



JUNE.



The firm top line is the Barometer reading at Kew taken 4 a.m. 10 a.m. 4 p.m & 10 p.m
The dotted top line is the Barometer reading at Glasgow taken do. do. do. do.
The lower lines are the Maxima and Minima temperatures at Kew & Glasgow observed respectively at 10 a.m & 10 p.m
Kew lines are firm Glasgow lines are dotted
The figures attached to the districts shew the Number of deaths caused by the explosions.

Inst. of Mining & Mechanical Engineers
Transactions 1890-91

APPENDIX VOL. XL PLATE.

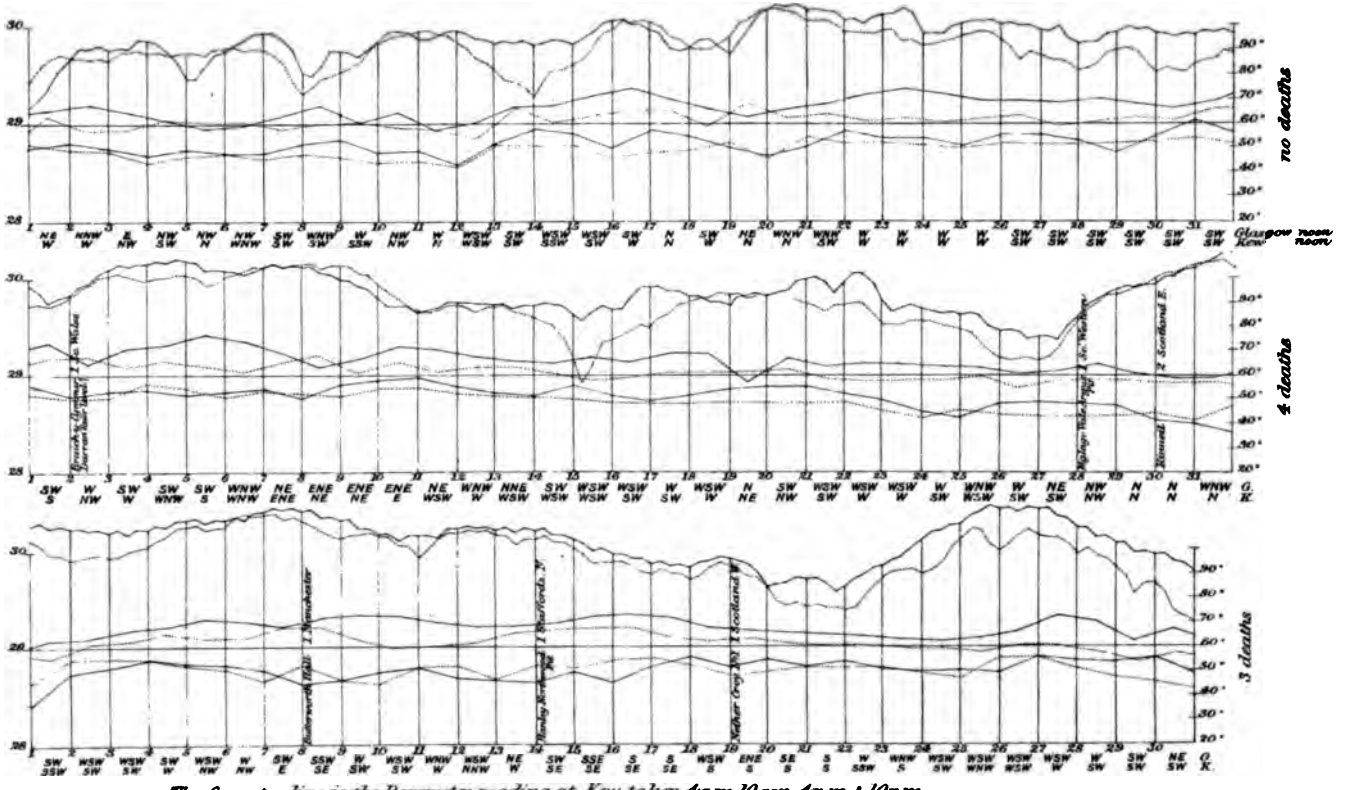
And.w Reid, Sons & Co. Lithos Newcastle.

1890.

JULY.

AUGUST.

SEPTEMBER.



The firm top line is the Barometer reading at Kew taken 1 a.m. 10 a.m. 4 p.m & 10 p.m.
The dotted top line is the Barometer reading at Glasgow taken do do. do. do.
The lower lines are the Maxima and Minima temperatures at Kew & Glasgow observed respectively at 10 a.m. & 10 p.m
Kew lines are firm Glasgow lines are dotted
The figures attached to the districts shew the Number of deaths caused by the explosions.

North of England Institute of Mining & Mechanical Engineers Transaction: 1890-91

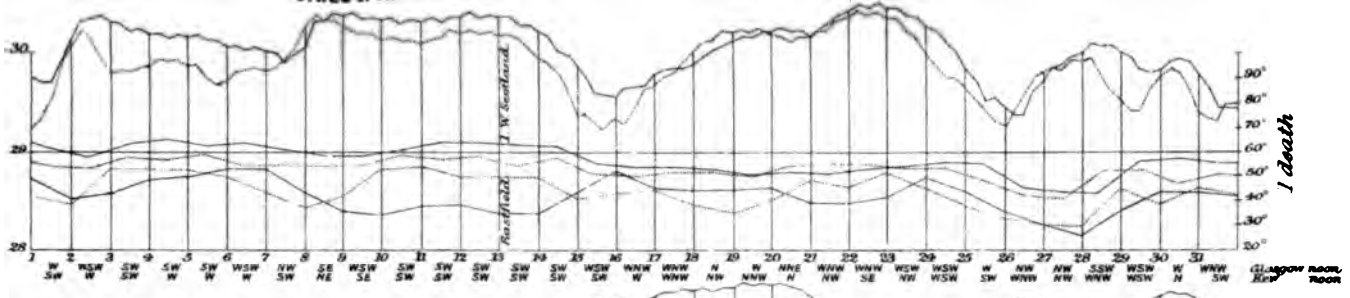
APPENDIX VOL. XL. PLAT.

And.w Reid Sons & Co Lithos. Newcastle

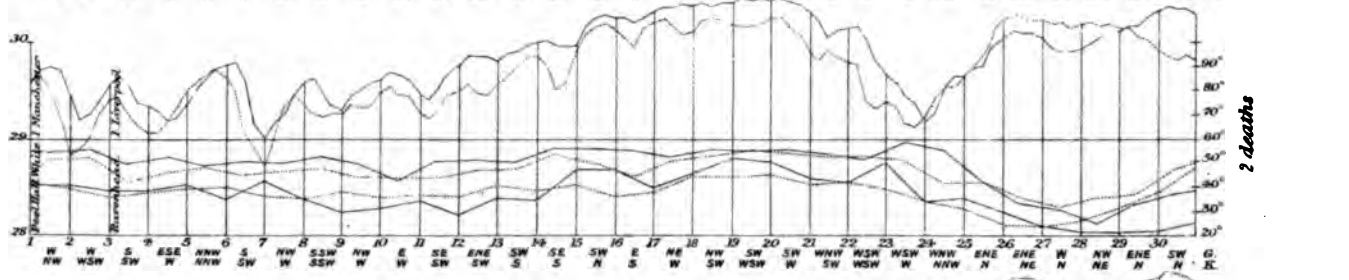
WIND AT THE OBSERVATORIES of KEW & GLASGOW TOGETHER WITH THE BAROMETER OF FIRETHARE IN ENGLAND & SCOTLAND.

1890.

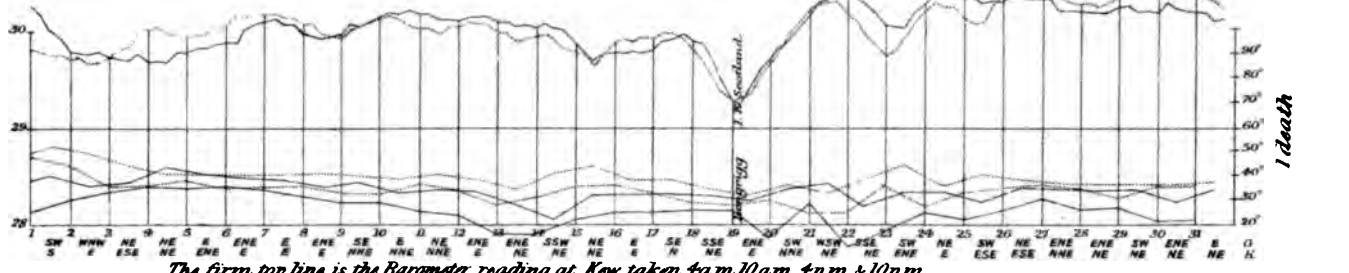
OCTOBER.



NOVEMBER.



DECEMBER.



The firm top line is the Barometer reading at Kew taken 4a.m. 10 a.m. 4p.m & 10p.m.
The dotted top line is the Barometer reading at Glasgow taken do. do. do. do.
The lower lines are the Maxima and Minima temperatures at Kew & Glasgow observed respectively at 10 a.m. & 10p.m.
Kew lines are firm Glasgow lines are dotted
The figures attached to the Districts show the Number of deaths recorded in them.

II.—REPORT OF THE CORRESPONDING SOCIETIES COMMITTEE OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.*

The Corresponding Societies Committee of the British Association beg to report to the General Committee that the two meetings of the Conference of Delegates were held on Thursday, September 12, and Tuesday, September 17, 1889, at 3 p.m., in the Committee Room of Section C, at Newcastle-upon-Tyne.

* * * * * * * * * * * * * *

At the first Conference the chair was taken by Mr. Francis Galton, the Corresponding Societies Committee being also represented by Dr. John Evans, Mr. W. Whitaker, and Mr. W. Topley.

* * * * * * * * * * * * * *

No statements were made respecting Sections A. and B.

SECTION C.

Erratic Boulders, &c.—

* * * * * * * * * * * * * *

Geological Photography.—Mr. Knubley next referred to the subject of geological photography, which had been brought forward in 1888. It was then felt that the proposal was too vague to bring in any definite form before the different societies, but the matter had become more definite in the course of the year, and he thought that the time had arrived for proposing that a Committee should be formed to arrange the collection of photographic views illustrating the geological features of each county of the United Kingdom.

A discussion ensued as to the mode of procedure to be adopted in order to give practical effect to the conclusions already arrived at by those members of the Corresponding Societies who had been working at the subject during the year.

Mr. O. W. Jeffs, having been called upon by the Chairman, stated that the matter had been brought before the Delegates at Bath in 1888, and had been discussed on that occasion. The proposal had then been left in an informal condition, and he undertook to communicate with the Delegates of the different geological societies of the kingdom. He had done this in an unofficial and private circular, and now had a list of what each had obtained, as well as a large collection of photographs, some of which were very interesting. He added that he had received letters from a large number of Delegates highly approving of the scheme, and offering suggestions. These letters would be placed at the disposal of Section C or of anyone taking the matter up.

No formal recommendation with respect to the subject was passed at the Conference, as the matter was to be brought before the Committee of Section C the following day.

* Reprinted by special permission of the Council of the British Association.

NOVEMBER, 1890.

KEW.								GLASGOW.							
	Barometer.				Temperature.				Barometer.				Temperature.		
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon
1	29·563	29·719	29·754	29·723	54·1	41·6	NW	1	29·590	29·647	29·556	29·230	51·2	42·0	W
2	29·442	29·202	29·242	29·364	55·6	41·6	WSW	2	28·837	28·904	29·002	29·285	52·6	40·0	W
3	29·560	29·655	29·544	29·381	49·2	39·0	SW	3	29·426	29·424	29·244	29·150	43·6	36·3	S
4	29·344	29·273	29·195	29·221	52·3	38·9	W	4	29·084	29·090	29·159	29·346	46·6	38·2	ESE
5	29·365	29·534	29·625	29·718	49·1	40·9	NNW	5	29·509	29·600	29·678	29·727	48·5	39·0	NNW
6	29·768	29·795	29·598	29·160	50·0	36·3	SW	6	29·663	29·509	29·065	28·635	46·2	40·0	S
7	28·997	29·169	29·286	29·465	49·5	42·5	W	7	28·723	29·109	29·364	29·462	47·2	36·2	NW
8	29·596	29·618	29·485	29·332	51·9	36·6	SSW	8	29·361	29·287	29·221	29·241	48·5	36·0	SSW
9	29·305	29·427	29·495	29·569	49·3	30·2	W	9	29·268	29·334	29·318	29·322	44·0	38·6	NW
10	29·602	29·677	29·659	29·609	43·2	31·4	W	10	29·477	29·536	29·433	29·441	43·4	35·8	E
11	29·476	29·394	29·528	29·656	49·9	34·0	SW	11	29·283	29·205	29·303	29·440	44·3	37·2	SE
12	29·742	29·845	29·854	29·856	50·6	29·1	SW	12	29·499	29·560	29·482	29·436	47·0	36·7	ENE
13	29·796	29·880	29·904	29·953	50·0	35·6	S	13	29·559	29·648	29·745	29·854	47·8	40·5	SW
14	29·969	30·019	29·978	29·961	56·1	35·8	S	14	29·848	29·778	29·507	29·571	53·7	38·6	SE
15	29·984	30·160	30·252	30·291	55·9	47·2	N	15	29·902	30·080	30·145	30·197	49·7	41·1	SW
16	30·254	30·257	30·197	30·258	54·8	47·0	S	16	30·144	30·044	29·974	30·122	44·3	36·6	E
17	30·318	30·378	30·370	30·396	52·5	40·2	W	17	30·199	30·230	30·150	30·075	50·8	37·0	NE
18	30·371	30·395	30·387	30·408	54·4	46·1	SW	18	30·094	30·213	30·243	30·236	51·6	45·3	NW
19	30·407	30·446	30·433	30·450	55·1	51·5	WSW	19	30·178	30·180	30·190	30·266	54·8	43·6	SW
20	30·436	30·473	30·436	30·396	55·1	50·1	W	20	30·258	30·263	30·159	30·070	53·3	44·6	SW
21	30·308	30·202	30·022	30·100	53·2	43·3	SW	21	29·904	29·808	29·901	29·861	51·6	40·4	WNW
22	30·123	30·149	30·036	29·805	50·7	41·0	WSW	22	29·799	29·797	29·489	29·399	51·3	41·4	WSW
23	29·647	29·580	29·443	29·354	58·3	49·8	W	23	29 370	29·311	29·169	29·119	50·3	39·5	WSW
24	29·168	29·278	29·517	29·618	55·0	35·2	NNW	24	29·203	29·431	29·490	29·550	41·2	34·5	WNW
25	29·620	29·709	29·778	29·941	41·7	31·4	N	25	29·615	29·877	30·088	30·192	41·4	34·8	ENE
26	30·029	30·109	30·098	30·088	34·1	25·5	NE	26	30·226	30·294	30·270	30·251	36·5	30·0	ENE
27	30·035	29·952	29·903	29·907	31·0	23·2	N	27	30·212	30·194	30·157	30·182	32·3	23·4	W
28	29·911	29·976	30·015	30·092	25·5	21·5	NE	28	30·177	30·207	30·165	30·181	36·1	25·8	NW
29	30·098	30·134	30·168	30·251	33·1	21·6	N	29	30·148	30·143	30·068	30·005	37·4	31·0	ENE
30	30·310	30·375	30·353	30·355	37·2	21·5	N	30	29·911	29·866	29·819	29·846	47·2	37·4	SW

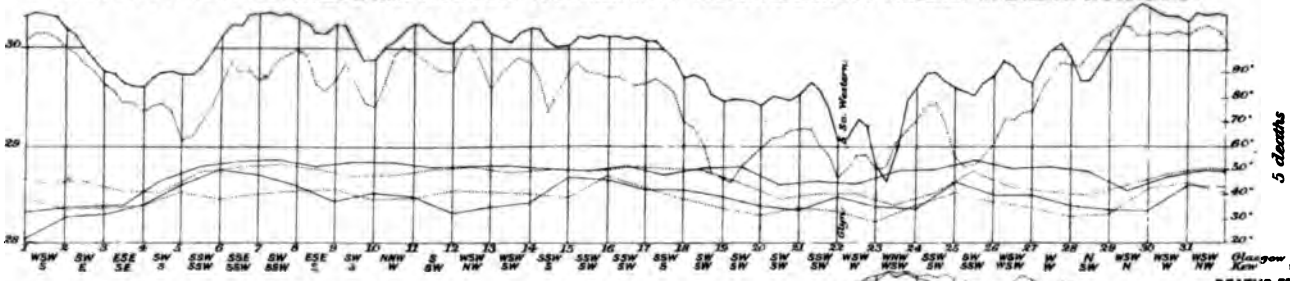
DECEMBER, 1890.

1	30·251	30·179	29·999	29·900	39·9	25·5	S	1	29·805	29·790	29·752	29·745	51·8	48·0	SW
2	29·771	29·775	29·747	29·770	35·8	30·3	E	2	29·705	29·715	29·657	29·686	49·4	44·3	WNW
3	29·716	29·704	29·690	29·747	38·6	34·4	ESE	3	29·712	29·802	29·873	30·017	44·2	36·5	NE
4	29·687	29·682	29·683	29·760	43·8	36·1	NE	4	30·005	30·016	29·980	29·970	41·0	35·9	NE
5	29·786	29·815	29·811	29·859	40·7	35·5	ENE	5	29·943	29·963	29·984	30·043	40·2	37·6	E
6	29·877	29·969	30·013	30·072	39·1	36·0	E	6	30·087	30·142	30·150	30·203	40·0	35·5	ENE
7	30·092	30·117	30·064	30·043	38·8	33·9	E	7	30·196	30·186	30·139	30·120	40·0	34·0	E
8	29·973	29·939	29·911	29·934	35·4	31·1	E	8	30·088	30·062	29·978	29·949	40·2	34·1	ENE
9	29·957	30·049	30·039	30·085	36·9	28·8	NNE	9	29·916	29·999	30·017	30·083	40·1	32·4	SE
10	30·115	30·190	30·172	30·205	32·2	28·7	NNE	10	30·113	30·149	30·105	30·060	39·1	32·6	E
11	30·182	30·173	30·107	30·094	33·1	24·3	NNE	11	30·019	30·007	29·986	30·011	40·2	36·1	NE
12	30·085	30·128	30·111	30·124	32·8	22·9	E	12	30·025	30·078	30·080	30·064	38·1	33·5	ENE
13	30·088	30·086	30·023	30·022	28·2	16·4	NE	13	29·992	29·958	29·894	29·906	34·1	28·4	ENE
14	30·010	30·050	30·009	29·985	21·5	16·7	NE	14	29·927	29·951	29·889	29·803	40·6	30·7	SSW
15	29·865	29·735	29·653	29·724	31·2	21·2	NE	15	29·774	29·730	29·723	29·854	43·2	35·1	NE
16	29·767	29·764	29·752	29·758	31·2	24·4	E	16	29·859	29·895	29·894	29·910	38·1	35·0	E
17	29·781	29·864	29·894	29·938	32·0	24·4	N	17	29·914	29·957	29·946	29·908	38·2	32·2	SE
18	29·888	29·854	29·681	29·488	30·9	25·1	NE	18	29·802	29·682	29·514	29·357	33·6	28·7	SSE
19	29·240	29·217	29·354	29·541	29·5	25·0	E	19	29·251	29·257	29·337	29·495	30·9	27·3	ENE
20	29·651	29·800	29·878	30·061	33·7	15·5	NNE	20	29·637	29·772	29·884	30·041	35·6	29·2	SW
21	30·117	30·271	30·299	30·349	36·2	27·2	NE	21	30·179	30·273	30·293	30·279	32·1	24·3	WSW
22	30·310	30·337	30·241	30·154	27·1	10·8	NE	22	30·182	30·104	29·950	29·834	37·9	24·3	SSE
23	30·038	30·012	30·000	30·120	32·1	17·8	ENE	23	29·729	29·763	29·893	30·073	43·9	35·0	SW
24	30·242	30·346	30·329	30·362	32·1	24·0	E	24	30·185	30·270	30·237	30·216	35·3	27·0	NE
25	30·311	30·362	30·248	30·278	29·2	21·2	ESE	25	30·120	30·059	30·061	30·226	40·0	32·1	SW
26	30·288	30·324	30·314	30·302	34·0	24·8	ESE	26	30·340	30·434	30·436	30·440	38·8	33·2	NE
27	30·306	30·301	30·192	30·188	33·2	29·8	NNE	27	30·383	30·371	30·310	30·292	36·4	34·5	ENE
28	30·180	30·172	30·164	30·182	32·9	25·9	NE	28	30·246	30·248	30·226	30·266	35·7	33·7	ENE
29	30·207	30·227	30·178	30·180	32·8	26·2	NE	29	30·313	30·380	30·376	30·397	35·3	29·9	SW
30	30·171	30·245	30·201	30·181	28·2	20·7	NE	30	30·441	30·510	30·493	30·455	36·5	34·7	ENE
31	30·165	30·150	30·075	30·101	33·2	20·8	NE	31	30·348	30·305	30·260	30·198	37·5	35·7	E

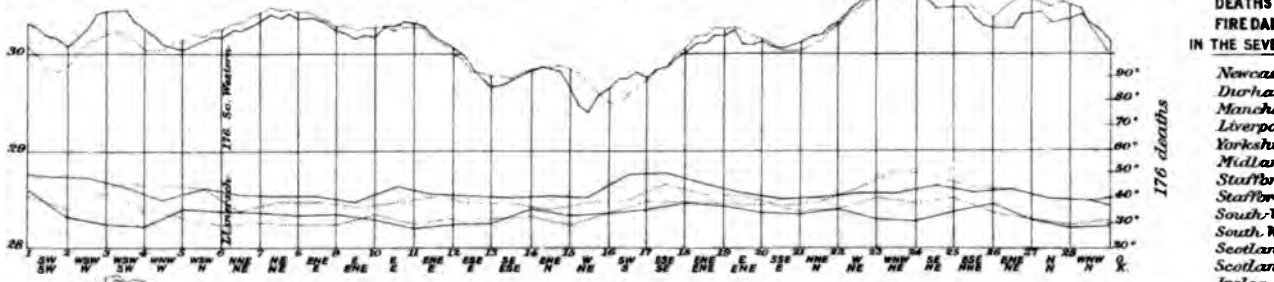
DIAGRAM SHEWING THE HEIGHT OF THE BAROMETER, THE MAXIMA & MINIMA TEMPERATURES & THE DIRECTION OF THE WIND AT THE OBSERVATORIES OF KEW & GLASGOW TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND.

1890.

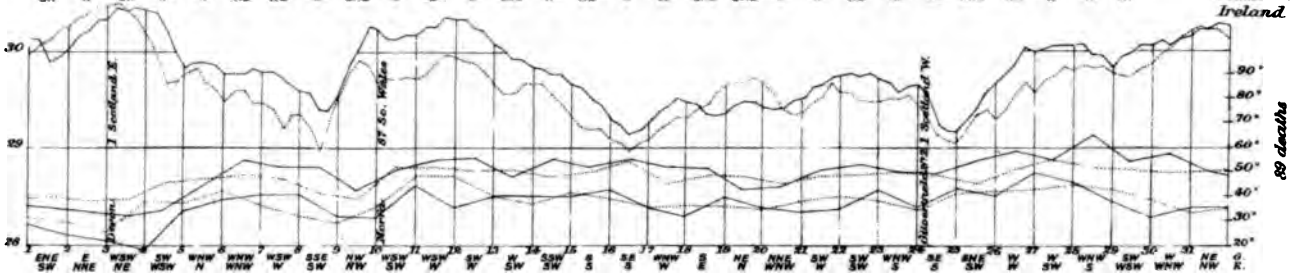
JANUARY.



FEBRUARY.



MARCH.



DEATHS FROM EXPLOSIONS OF FIREDAMP DURING THE YEAR 1890. IN THE SEVERAL INSPECTION DISTRICTS.

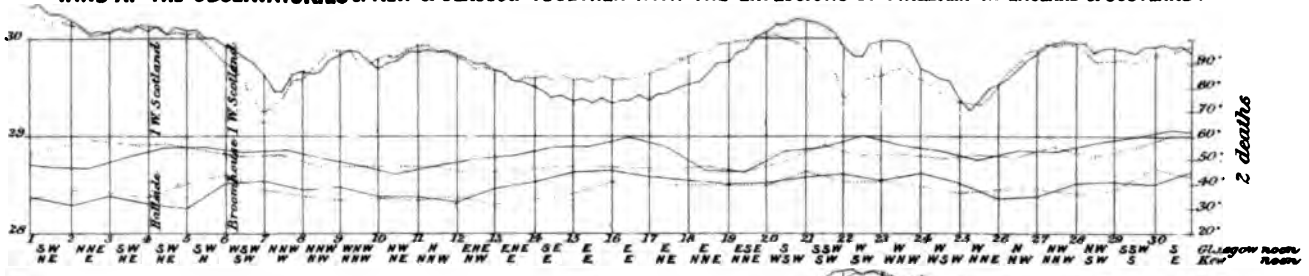
Newcastle	0 Deaths
Durham	0 .
Manchester	2 .
Liverpool	1 .
Yorkshire	2 .
Midland	0 .
Staffordshire, North	2 .
Staffordshire, South	0 .
South-Western	182 .
South Wales	91 .
Scotland, East	5 .
Scotland, West	5 .
Ireland	0 .
Total	290

The firm top line is the Barometer reading at Kew taken 4 a.m. 10 a.m. 4 p.m. & 10 p.m.
The dotted top line is the Barometer reading at Glasgow taken do. do. do. do.
The lower lines are the Maxima and Minima temperatures at Kew & Glasgow observed respectively at 10 a.m. & 10 p.m.
Kew lines are firm Glasgow lines are dotted

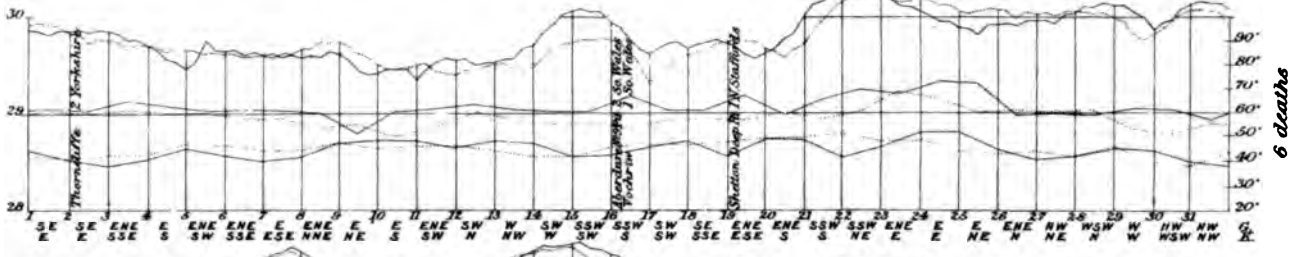
DIAGRAM SHEWING THE HEIGHT OF THE BAROMETER, THE MAXIMA & MINIMA TEMPERATURES & THE DIRECTION OF THE WIND AT THE OBSERVATORIES of KEW & GLASGOW TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND.

1890

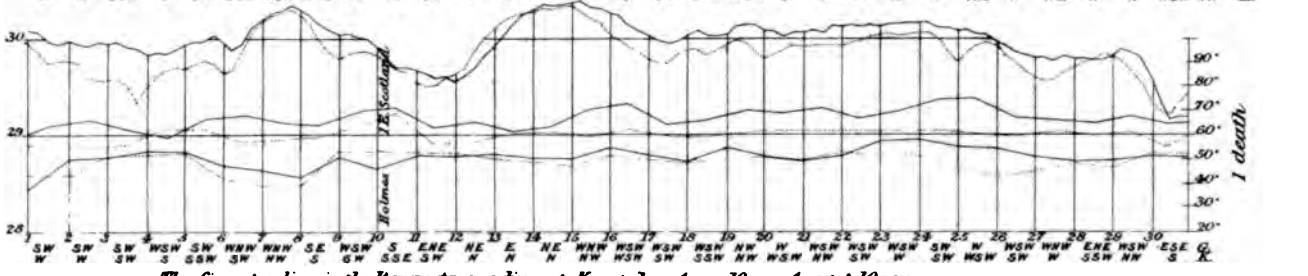
APRIL.



MAY



JUNE.



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Kew lines are firm Glasgow lines are dotted
The figures attached to the districts show the Number of deaths caused by the explosions.

Inst. Institute of Mining & Mechanical Engineers
Transactions 1890-91

APPENDIX VOL. XL 1ST PLATE.

And[w] Reid, Sons & Co[y] Lithos, Newcastle

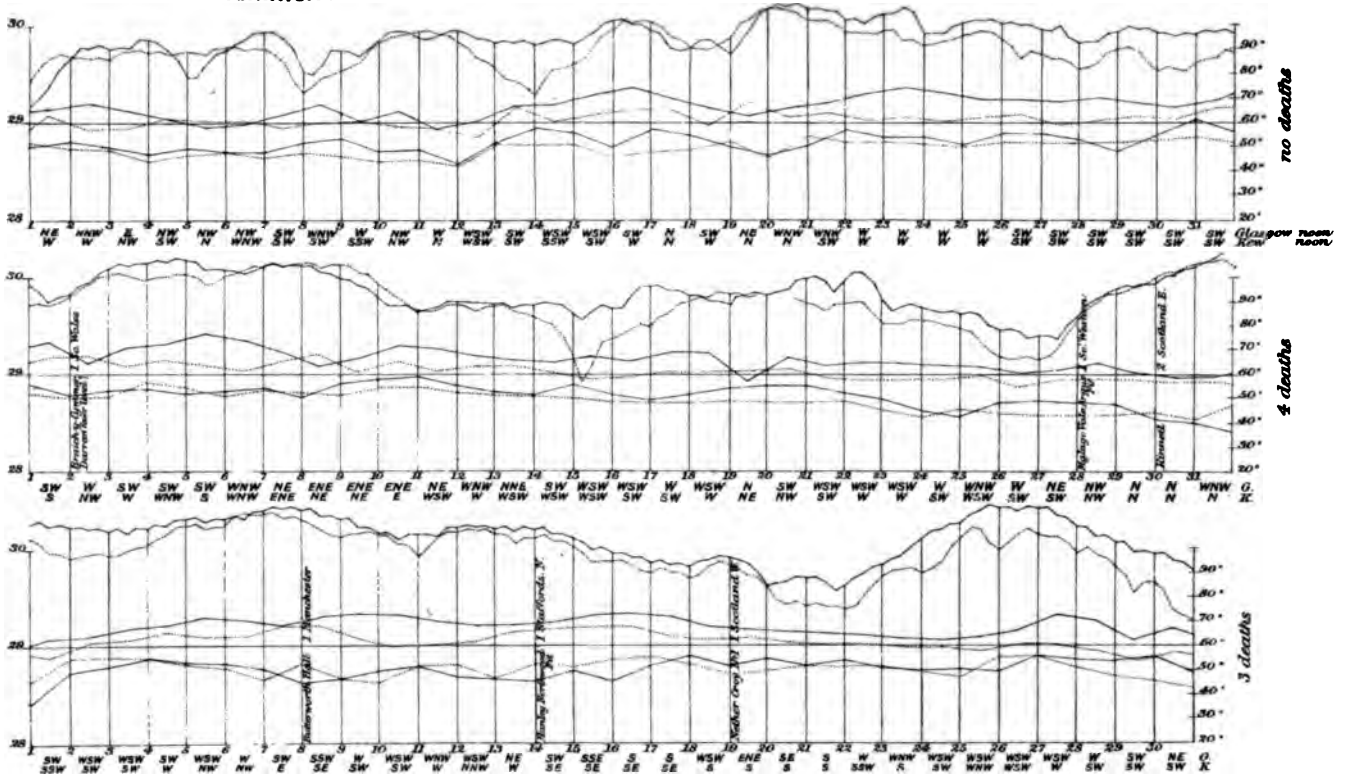
DIAGRAM SHEWING THE HEIGHT OF THE BAROMETER, THE MAXIMA & MINIMA TEMPERATURES & THE DIRECTION OF THE WIND AT THE OBSERVATORIES of KEW & GLASGOW TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND.

1890.

JULY.

AUGUST.

SEPTEMBER.



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And.w Reid Sons & Co. Lithos Newcastle

THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR 1889-90.—*Continued.*

Full Title and Date of Foundation.	Abbreviated Title.	Head-quarters or Name and Address of Secretary.	No. of Members.	Entrance Fee.	Annual Subscription.	Title and Frequency of Issue of Publications.
Manchester Geographical Society, 1885	Manch. Geog. Soc. ..	Eli Sowerbutts, F.R.G.S., 44, Brown Street, Manchester	800	None	Ordinary, £1 1s.; Associates, 10s. 6d.	Journal, quarterly.
Manchester Geological Society, 1838..	Manch. Geol. Soc. ..	Mark Stirrup, F.G.S., 36, George Street, Manchester	213	None	£1.	Transactions, about nine parts per annum.
Manchester Statistical Society, 1833 ..	Manch. Stat. Soc. ..	25, Booth Street, Manchester. Francis E. M. Beardsall and G. H. Pownall	Ordinary, 184	10s. 6d.	10s. 6d.	Transactions, annually.
Marlborough College Natural History Society, 1864	Marlb. Coll. N. H. Soc.	Marlborough College. E. Meyrick ..	250	1s. 6d.	3s.	Report, annually.
Midland Union of Natural History Societies, 1877	Mid. Union	W. K. Parkes, 61, Cavendish Road, and Dr. Lawson Tait, The Crescent, Birmingham	2,000	—	—	"Midland Naturalist," monthly.
North of England Institute of Mining and Mechanical Engineers, 1852	N. Eng. Inst.	Prof. G. A. Lebour, Neville Hall, Newcastle-upon-Tyne	730	None	21s., 42s., 63s.	Transactions, about every two months.
North Staffordshire Naturalists' Field Club and Archæological Society, 1865	N. Staff. N. F. C. A. Soc.	Rev. T. W. Daltry, M.A., Madeley Vicarage, Newcastle, Staffs.	374	5s.	5s.	Report and Transactions, annually.
Northamptonshire Natural History Society and Field Club, 1885	N'ton N. H. Soc. ..	The Museum, Guildhall Road, Northampton. H. N. Dixon	200	None	10s.	Journal, quarterly.
Nottingham Naturalists' Society, 1852	Nott. Nat. Soc.	W. B. Winnicott, Burton Joyce, near Nottingham	Honorary, 8; Ordinary, 137; Corresponding, 8	None None None	None 5s. s. 6d.	Transactions and Report, annually.
Paisley Philosophical Institution, 1808	Paisley Phil. Inst. ..	J. Gardner, 3, County Place, Paisley	300	5s.	7s. 6d.	Report, annually.
Penzance Natural History and Antiquarian Society, 1839.	Penz. N. H. A. Soc. ..	G. F. Tregelles, Devon and Cornwall Bank, Penzance	93	None	10s. 6d.	Report and Transactions, annually.
Perthshire Society of Natural Science, 1867	Perths. Soc. N. Sci. ..	Tay Street, Perth. S. T. Ellison ..	314	2s. 6d.	5s. 6d.	Transactions and Proceedings, annually.
Rochdale Literary and Scientific Society, 1878	Rochdale Lit. Sci. Soc.	J. Reginald Ashworth, 20, King Street South, Rochdale	277	None	5s.	Transactions, occasionally.
Rochester Naturalists' Club, 1878 ..	Rochester N. C.	John Hepworth, Union Street, Rochester	120	None	3s. 6d., 5s., and 10s.	"Rochester Naturalist," quarterly.
Royal Scottish Geographical Society, 1884	R. Scot. Geog. Soc. ..	National Portrait Gallery, Edinburgh. A. Silva White	1,546	None	£1 1s.	"Scottish Geographical Magazine," monthly.
South African Philosophical Society, 1877	S. African Phil. Soc. ..	David Gill, F.R.S., Royal Observatory, Cape Town	72	None	£2.	Transactions, annually.
Warwickshire Naturalists' and Archæologists' Field Club, 1854	Warw. N. A. F. C. ..	W. G. Fretton, F.S.A., Hearsall Terrace, Chapel Fields, Coventry	66	2s. 6d.	5s.	Proceedings, annually.
Woolhope Naturalists' Field Club, 1851	Woolhope N. F. C. ..	Woolhope Club Room, Free Library, Hereford. H. Cecil Moore	About 200	10s.	10s.	Transactions, annually.
Yorkshire Geological and Polytechnic Society, 1837	Yorks. Geol. Poly. Soc.	James W. Davis, F.G.S., Chevinedge, Halifax	250	None	13s.	Proceedings, annually.
Yorkshire Naturalists' Union, 1861 ..	Yorks. Nat. Union ..	W. Denison Roebuck, Sunny Bank, Leeds; and Rev. E. P. Knubley, Staveley Rectory, Leeds	410 and 2,517 Associates	None	10s. 6d.	Transactions, annually; "The Naturalist," monthly.

INDEX OF THE MORE IMPORTANT PAPERS, AND ESPECIALLY THOSE REFERRING TO LOCAL SCIENTIFIC INVESTIGATIONS, PUBLISHED BY THE ABOVE-NAMED SOCIETIES DURING THE YEAR ENDING JUNE 1, 1890.*

Section A.—MATHEMATICAL AND PHYSICAL SCIENCE.

Name of Author.	Title of Paper.	Abbreviated Title of Society.	Title of Publication.	Volume or Part.	Page.	Published.
Andrews, J. D. F.	The Wiring of Buildings for Electric Light	Glasgow Phil. Soc.	*Proc.*	XX.	225	1889
Morris, T.	Some Causes of the Crystallization of Iron	Liv'pool E. Soc.	*Trans.*	X.	108	"
Sinclair, D.	Multiplex Telephony on Long Lines	Glasgow Phil. Soc.	*Proc.*	XX.	128	"

Section B.—CHEMICAL SCIENCE.

Name of Author.	Title of Paper.	Abbreviated Title of Society.	Title of Publication.	Volume or Part.	Page.	Published.
Atkinson, A. J.	On the Development of the Basic Process of Steel-making	Cardiff Nat. Soc.	*Report and Trans.*	XXI.	20	1890
Dickinson, J.	On Carbonic Acid Gas or Black Damp	Manch. Geol. Soc.	*Trans.*	XX.	256	1889
Hewitt, J. T.	Analysis of Lias Mortar from Southampton Docks	Hants. F. C.	*Proc.*	III.	92	"
Johnstone, A.	Improved Methods of Determining the Composition of Minerals by Blow-pipe Analysis	Edinb. Geol. Soc.	*Trans.*	VI.	43	1890
Meldola, Prof. R.	The late Col. Russell's Contributions to Photography	Essex F. C.	*Essex Naturalist*	III.	117	1889
Turner, T.	On the Colours produced during the Tempering of Steel	Birm. Phil. Soc.	*Proc.*	VI.	296	"

Section C.—GEOLOGY.

Name of Author.	Title of Paper.	Abbreviated Title of Society.	Title of Publication.	Volume or Part.	Page.	Published.
Adamson, S. A.	Reports on Excursions	Leeds Geol. Assoc.	*Trans.*	V.	51-76	1890
" "	At the Foot of the Wolds	Yorks. Nat. Union	*The Naturalist*	For 1889	179	1889
" "	The Yorkshire Boulder Committee and its Third Year's Work	" "	" "	"	293	"
" "	Geological Papers relating to the North of England	" "	" "	For 1890	12	1890
Beasley, H. C.	Presidential Address	Liv'pool Geol. Soc.	*Proc.*	VI.	11	1889
Bird, W. J.	Note on Seaton Carew Boring	Manch. Geol. Soc.	*Trans.*	XX.	263	"
Brodie, Rev. P. B.	On the Predominance and Importance of the Blattidæ in the Old World	Warw. N. A. F. C.	*Proc.*	33	12	"
Browett, A.	The Bath Oolite and Method of Quarrying	Birm. N. H. M. Soc.	*Mid Naturalist*	XII.	187	"
" "	The Bath Oolite	Mid Union	" "	"	"	"

* The Titles of Papers on other than Mining and Mechanical Engineering, etc., have not been reprinted

Name of Author.	Title of Paper.	Abbreviated Title of Society.	Title of Publication.	Volume or Part.	Page.	Published.
Callaway, Dr. C.	Notes of the Quarternary Deposits of Shropshire	Mid. Union	*Mid. Naturalist*	XIII.	110	1890
Christy, R. W.	Notes on the Geology of the District around Chelmsford, with a List of the Mollusca from the Alluvium at Roxwell, Essex	Essex F. C.	*Essex Naturalist*	III.	171	1889
Clifford, W.	Additional Notes on Richmond Coal-field, Virginia	Manch. Geol. Soc.	*Trans.*	XX.	247	"
Coates, H.	The Arrangement of the Perthshire Geological Collection in the Museum: Rock Specimens	Perths. Soc. N. Sci.	*Trans. and Proc.*	I.	105	"
Cole, Rev. E. M.	Notes on the Driffield and Market Weighton Railway	Yorks. Geol. Poly. Soc.	*Proc.*	XI.	170	1890
Dalton, W. H.	On the Upper Clay of Walton Naze	Essex F. C.	*Essex Naturalist*	III.	223	1889
"	Fowlness	"	"	"	239	"
Davis, J. W.	Biographical Notices of Eminent Yorkshire Geologists: No. iv., Hugh E. Strickland, F.R.S., etc.	Yorks. Geol. Poly. Soc.	*Proc.*	XI.	139	1890
" "	Fossil Fish-remains from Carboniferous Shells at Cultra, Co. Down, Ireland	" " "	"	"	332	"
" "	Summary of Geological Literature relating to Yorkshire published during 1889	" " "	"	"	344	"
Davison, C.	On the Secular Straining of the Earth	Birm. Phil. Soc.	"	VI.	307	1889
Dawkins, Prof. W. Boyd	On the Discovery of Coal-measures near Dover	Manch. Geol. Soc.	*Trans.*	XX.	502	1890
De Rance, C. E.	Notes on the Geology of the Manchester Canal	Chesterf. Mid. Count. In.	*Trans. and Proc.*	I.	1	"
"	Underground Water Supply and River Floods	Yorks. Geol. Poly. Soc.	*Proc.*	XI.	200	"
Deacon, G. F.	The Glacial Geology of the Vyrnwy Valley	Liv'pool Geol. Soc.	"	VI.	66	1889
Deane, Rev. G.	The Geology and Travels of Jean André De Luc	Birm. Phil. Soc.	"	"	261	"
Dickson, E., and P. Holland	Examination of some Volcanic Rocks of the Isle of Man	Liv'pool Geol. Soc.	"	"	123	"
Dow, R.	Geological Notes on Loch Carron and West Ross-shire	Perths. Soc. N. Sci.	*Trans. and Proc.*	I.	98	"
Dowker, G.	The Probability of finding Coal in Kent	E. Kent N. H. Soc.	*Trans.*	3 and 4	130	"
Farrar, A., jun.	A Remnant of Pre-glacial England; or Holiday Notes on the Cromer Forest Bed	Leeds Geol. Assoc.	"	V.	41	1890
Fitton, W. H.	One of Nature's Gems	"	"	"	31	"
Fitzpatrick, J. J.	The Permian Conglomerate and other Palæozoic Rocks to the North of Morecambe Bay	Liv'pool Geol. Soc.	*Proc.*	VI.	42	1889
Forrester, J.	Sand	E. Scot. Union	"	For 1889	10	1890
Fox, H.	On the Junction of Hornblende Schist and Serpentine in the Ogo Dour District	Cornwall R. Geol. Soc.	*Trans.*	XI.	213	"
Goodchild, J. G.	The History of the Eden and of some Rivers adjacent	Cumb. West. Assoc.	"	XIV.	73	1889
Groves, T. B.	The Erosion of the Coast near Weymouth by the Action of the Sea	Dorset N. H. A. F. C.	*Proc.*	X.	180	"
Hardcastle, C. D.	The Physical Features of Ingleton	Leeds Geol. Assoc.	*Trans.*	V.	16	1890
Harker, Alfred	Petrological Notes on some Boulders from the Boulder Clays of East Yorkshire	Yorks. Geol. Poly. Soc.	"	XI.	300	"
" "	Notes on North of England Rocks	Yorks. Nat. Union	*The Naturalist*	For 1889	207	1889
" "	Bibliography for North of England, 1888: Geology and Palæontology	" " "	"	"	121	1890
Haviland, A.	The Necessity for Collecting and Arranging the ascertained Facts relating to the Glaciation of the Isle of Man	I. of Man N. H. A. Soc.	*Yn Lioar Manninagh*	I.	57	"
" "	Aspects of Crags of the Manks Mountains in relation to the Glaciation of the Island	" " "	"	"	77	"
Henderson, J.	On the Succession of the Lower Carboniferous Series to the West of Edinburgh	Edinb. Geol. Soc.	*Trans.*	VI.	29	1890

Section C.—GEOLOGY.—*Continued.*

Name of Author.	Title of Paper.	Abbreviated Title of Society.	Title of Publication.	Volume or Part.	Page.	Published.
Hick, T., and W. Cash	The Structure and Affinities of Lepidodendron	Yorks. Geol. Poly. Soc.	*Proc.*	XI.	316	1890
Holmes, T. V.	Notes on the Geology of Maldon and the Blackwater Estuary	Essex F. C.	*Essex Naturalist*	III.	111	"
Holmes, T. V.	Recent Subsidences near Stifford, Essex	Essex F. C.	*Essex Naturalist*	III.	183	1889
" "	The Geology of South Essex	" "	"	"	214	"
Hull, Prof. E.	On the probable Average Depth at which Coal is now being worked in the British Isles	Manch. Geol. Soc.	*Trans.*	XX.	417	"
Jefferson, S.	Minerals as Gems and Precious Stones	Leeds Geol. Assoc.	"	V.	45	1890
Johnston-Lavis, Dr. H. J.	The State of the Active Sicilian Volcanoes in September, 1889	R. Scot. Geog. Soc.	*Magazine*	VI.	145	"
Johnstone, A.	The Classification, Determination, Distribution, Origin, and Evolution of the Normal Micas	Edinb. Geol. Soc.	*Trans.*	17	"	"
Jones, Rev. E.	On the Further Exploration of a Cave at Elbolton, near Thorpe, in Craven	Yorks. Geol. Poly. Soc.	*Proc.*	XI.	307	"
Kemp, J. T.	The Tufaceous Deposits of the Test and Itchen	Hants. F. C.	"	III.	83	1889
Kermode, P. M. C.	Fossil Shells from the Boulder Clay and Sand, North Ramsey	I. of Man N. H. Soc.	*Yn Lioar Manninagh*	I.	96	"
Kidson, E.	Further Evidences of Glacial Action in Snowdonia	Nott. Nat. Soc.	*Trans.*	For 1889	14	1890
Lamplugh, G. W.	On the Larger Boulders of Flamborough Head, Parts II. and III.	Yorks. Geol. Poly. Soc	*Proc.*	XI.	231	"
" "	Glacial Sections near Bridlington	" "	"	"	275	"
Lomas, J.	Some Basaltic Dykes near Aros, Mull	Liv'pool Geol. Soc.	"	VI.	69	1889
Lupton, Prof. A.	On Gold, Slate, and Salt Mines in Great Britain	Yorks. Geol. Poly. Soc.	"	XI.	239	1890
McDakin, Capt.	Occurrence of Manganese in some Gravel Beds under Bigberry Wood, near Canterbury	E. Kent N. H. Soc.	*Trans.*	3 and 4	133	1889
" "	Some Remarks on the Lower Greensand, attributing the continuous Formation of Glauconite to the Potash set free by decaying Vegetation	" "	"	"	135	"
McMurtrie, J.	Comparison of the Somerset Coal-field with the Coal-measures of Belgium and the North of France	Bath N. H. A. F. C.	*Proc.*	VII.	49	1890
McNair, P.	The Arrangement of the Perthshire Geological Collection in the Museum: The Minerals	Perth Soc. N. Sci.	*Trans. and Proc.*	I.	110	1889
" "	On the Occurrence of supposed Annelid Tubes in the Quartzites of Perthshire	" "	"	"	116	"
Mansell-Pleydell, J. C.	Note on *Elephas meridionalis* found at Dawlish	Dorset N. H. A. F. C.	*Proc.*	X.	1	"
" "	*Bos primigenius*	" "	"	"	81	"
" "	*Crinodiosaurus Richardsoni*	" "	"	"	171	"
Marr, J. E.	The Connection betwixt Yorkshire and Scandinavia	Yorks. Nat. Union	*The Naturalist*	For 1890	145	1890
Marshall, W. P.	Recent Fall of Rock at Niagara Falls	E. Kent. N. H. Soc.	*Trans.*	3 and 4	139	1889
Mayon, R. W.	A Lump of Coal	Rochester N. C.	*Roch. Naturalist*	28	457	1890
Miller, Hugh	Supposed High-Level Shell Beds in E. Ross	Edin. Geol. Soc.	*Trans.*	VI.	28	"
Mitchell, T. C.	On the Drift-Deposits of the Vale of Mowbray	Yorks. Geol. Poly. Soc.	*Proc.*	XI.	177	"
Moran, Dr. J.	Mammoth's Tooth recently Found in the Drift Gravels at Larne Harbour	Belfast N. H. Phil. Soc.	*Report and Proc.*	For 1888-89	35	1889
Morgan, Prof. C. Ll.	The Geology of Tytherington and Grovesend	Bristol Nat. Soc.	*Proc.*	VI.	1	"
Morison, Dr. J.	Notes on the Chalk Rock	Herts. N. H. Soc.	*Trans.*	V.	199	"
Morton, G. H.	Further Notes on the Stanlow, Ince, and Frodsham Marshes	Liv'pool Geol. Soc.	*Proc.*	VI.	50	"
" "	Some Faults exposed in Shafts and Borings in the Neighbourhood of Liverpool	" "	"	"	115	"
Nicholson, Prof. H. A.	Address on Recent Progress in Palæontology as regards Invertebrate Animals	Edinb. Geol. Soc.	*Trans.*	"	53	1890

Section C.—GEOLOGY.—*Continued.*

Name of Author.	Title of Paper.	Abbreviated Title of Society.	Title of Publication	Volume or Part.	Page.	Published.
Picton, Sir J. A.	Notes on the Local Historical Changes in the Surface of the Land in and about Liverpool	Liv'pool Geol. Soc. ..	*Proc.*	VI.	31	1889
.. ..	The Vyrnwy Valley: its Geological and Glacial History	.. ..	.. .. ..	..	74	..
Piper, G. H.	Ludlow and Aymestry Rocks of the Silurian System	Woolhope N. F. C. ..	*Trans.*	—	39	1890
.. ..	On the Coal-measures of the Clee Hills	.. .. ..	.. .. ..	—	82	..
.. ..	On the Passage Beds of the Old Red Sandstone at Ledbury	.. .. ..	.. .. ..	—	136	..
.. ..	On the Old Red Sandstone as seen from the Sugarloaf Mountain in the county of Monmouth on the 10th of July, 1885	.. .. ..	.. .. ..	—	313	..
Praeger, R. Ll.	Report on the Gravels and Associated Beds of the Curran, at Larne ..	Belfast Nat. F. C. ..	*Report and Proc.*, ..	III.	198	..
.. ..	A Contribution to the Post-Tertiary Fauna of Ulster	.. .. ..	.. .. ..	..	215	..
Quine, Rev. J.	Geological Report for 1888-9	I. of Man N. H. A. Soc.	*Yn Lioar Manninagh*	I.	73	1889
Reade, T. M.	The Advantage to the Civil Engineer of a Study of Geology	Liv'pool E. Soc.	*Trans.*	X.	36	..
.. ..	Slickensides and Normal Faults: the Characteristics and Causes	Liv'pool Geol. Soc. ..	*Proc.*	VI.	92	..
.. ..	Cause of the Colouration of Red Sandstones	Yorks. Nat. Union ..	*The Naturalist* ..	For 1890	1	1890
Reid, A. S.	On Time as a Geological Factor	E. Kent N. H. Soc. ..	*Trans.*	3 and 4	145	1889
Richardson, R.	Darwin's Geological Work	Edinb. Geol. Soc. ..	.. .. ..	VI.	1	1890
Roeder, C.	Some Notes on the Barton Section of the Manchester Ship Canal	Manch. Geol. Soc. ..	.. .. ..	XX.	285	1889
Rutley, F.	On a Specimen of Banded Serpentine from the Lizard, Cornwall	Cornw. R. Geol. Soc. ..	.. .. ..	XI.	238	1890
Saunders, Rev. M. B. ..	On Mr. Mellard Reade's Work on Mountain Building	Bristol Nat. Soc. ..	*Proc.*	VI.	63	1889
Shipman, J.	The Geology of Nottingham	Nott. Nat. Soc.	*Trans.*	For 1889	26	1890
Shore, T. W., and J. W. Elwes	The New Dock Excavation at Southampton	Hants. F. C.	*Proc.*	III.	43	1889
Stirrup, M.	Delegate's Report of the British Association Meeting at Newcastle-on-Tyne	Manch. Geol. Soc. ..	*Trans.*	XX.	394	..
.. ..	On an alleged recent Discovery of a Fossil Forest in Scotland	.. .. ..	.. .. ..	..	412	..
.. ..	On the Hydrology of the Causses of Languedoc; the Gorges of the Tarn, its Caverns and Subterranean Streams	.. .. ..	.. .. ..	..	446	1890
Stuart, M. G.	The Ridgway Fault	Dorset N. H. A. F. C. ..	*Proc.*	X.	55	1889
Tate, T.	Yorkshire Petrology: Part II.—Lamprophyres	Yorks. Geol. Poly. Soc.	.. .. ..	XI.	311	1890
Teall, J. J. H	Metamorphism in the Hartz and W. of England	Cornw. R. Geol. Soc. ..	*Trans.*	..	221	..
Timmins, A.	Notes on a few Borings and the Base of the New Red Sandstone in the Neighbourhood of Liverpool	Liv'pool Geol. Soc. ..	*Proc.*	VI.	56	1889
Tute, Rev. J. S.	Notes on some Singular Cavities in the Magnesian Limestone	Yorks. Geol. Poly. Soc.	.. .. ..	XI.	182	1890
Vine, G. R.	Notes on British Eocene Polyzoa	.. .. ..	.. .. ..	..	154	..
.. ..	A Monograph of Yorkshire Carboniferous and Permian Polyzoa. Part II.	.. .. ..	.. .. ..	..	184	..
.. ..	Further Notes on the Polyzoa of the Lower Greensand and the Upper Greensand of Cambridge. Part II	.. .. ..	.. .. ..	..	250	..
Walford, E. A.	On some Terraced Hill Slopes of the Midlands	N'ton N. H. Soc. ..	*Journal*	5	303	1889
Walkden, R.	On the *Stigmaria ficoides* found in a Mine at Over Darwen	Manch. Geol. Soc. ..	*Trans.*	XX.	461	1890
Waller, T. H.	Note on a Granite containing Lithia	Birm. N. H. M. Soc. ..	*Mid. Naturalist* ..	XII.	154	1889
.. ..	The Petrology of our Local Pebbles	.. .. ..	.. .. ..	..	174, 214, 286	..
.. ..	Notes on some Rock Specimens collected in Norway by C. Pumphrey ..	.. .. ..	.. .. ..	..	264	..
.. ..	The Processes of Crystallisation in Rocks	.. .. ..	.. .. ..	XIII.	14	1890
Ward, T.	On the Salt Deposits of the United States of America and Canada	Manch. Geol. Soc. ..	*Trans.*	XX.	471	..

Section C.—GEOLOGY.—*Continued.*

Name of Author.	Title of Paper.	Abbreviated Title of Society.	Title of Publication.	Volume or Part.	Page.	Published.
Watts, W.	Erratic Boulders and Boulder Clay in Castleshaw Valley	Manch. Geol. Soc.	*Trans.*	XX.	265	1889
Whitaker, W.	Some Essex Well Sections. Part II.	Essex F. C.	*Essex Naturalist*	III.	44	,,
,, ,,	On a Deep Channel of Drift in the Valley of the Cam, Essex	,, ,,	,, ,,	,,	140	,,
,, ,,	Hampshire Well Sections	Hants. F. C.	*Proc.*	,,	17	,,
Whitaker, W., and W. H. Dalton	List of Works on the Geology, etc., of Essex	Essex F. C.	*Essex Naturalist*	III.	61	1889
Whitley, N.	A Geological Note	Cornw. R. Geol. Soc.	*Trans.*	XI.	242	1890
Williams, H. W.	On Pembrokeshire as a Field for the Study of Geology	Manch. Geol. Soc.	,,	XX.	426	1889
Winwood, Rev. H. H.	Rhætic Section at Luckington, and additional Notes on the Vobster Quarry	Bath N. H. A. F. C.	*Proc.*	VII.	45	1890
Woodward, A. S.	The Application of the Laws of Comparative Osteology to the Palæontology of the Vertebrata	Leeds Geol. Assoc.	*Trans.*	V.	27	,,
,, ,,	The Fossil Sturgeon of the Whitby Lias	Yorks. Nat. Union	*The Naturalist*	For 1890	101	,,
	***Section D.*—BIOLOGY.**					
Baker, J. G.	North Yorkshire: Studies of its Botany, Geology, Climate, and Physical Geography. (Third instalment)	Yorks. Nat. Union	*Trans*	3	145	1889
White, J. W.	Flora of the Bristol Coal-field	Bristol Nat. Soc.	*Proc.*	VI.	18	1889
	***Section E.*—GEOGRAPHY.**					
Argyll, Duke of	Border Lands between Geology and Geography	R. Scot. Geog. Soc.	*Magazine*	VI.	169	1890
	***Section F.*—ECONOMIC SCIENCE AND STATISTICS.**					
Coffey, G.	The proposed Technical Instruction Bill and the Science and Art Department	Stat. Soc. Ireland	*Journal*	IX.	403	1889
Hall, H.	On the Duration of our Coal Supply	Manch. Geol. Soc.	*Trans.*	XX.	379	,,
Tonkin, J	The Steam Boilers Bill	Cornw. Min. Assoc. Inst.	,,	II.	76	,,

Section G.—MECHANICAL SCIENCE.

Name of Author.	Title of Paper	Abbreviated Title of Society.	Title of Publication.	Volume or Part.	Page.	Published.
Bamford, C. F.	Air Brakes	Liv'pool E. Soc	*Trans.*	IX.	57	1869
Beloe, C. H.	The Purification of Water and Sewage by the Magnetic Spongy Carbon Process	" "	"	X.	118	"
Brighthouse, A. W. ..	Some recent Experiments on Iron and Steel and Riveted Joints	" "	"	IX.	1	"
" " ..	Application of Atmospheric Air to produce Motive Power	" "	"	X.	54	"
Coke, G. E.	A recent Boring at Chesterfield with the Diamond Drill	Chesterf. Mid. Count. In.	*Trans. and Proc.*	I.	17	1869
Cotterell, A. P. J. .	Some Remarks on Sewerage Systems	Bristol Nat. Soc. ..	*Proc.*	VI.	93	1869
Crawford, G. E.	The Eiffel Tower	" "	"		142	"
Darbishire, C. H.	President's Inaugural Address	Liv'pool E. Soc.	*Trans.*	X.	1	"
Farren, G.	The Construction of small Breakwaters, and the Silting they give rise to ..	" "	"		92	"
Greenwell, G. C., jun. ..	Description of a Patent Screen	Manch. Geog. Soc. ..	"	XX.	440	1870
Hoey, D. G.	The Science of Ventilation as applied to Inhabited Interiors	Glasgow Phil. Soc. ..	*Proc.*		306	1869
Lewis, G.	Presidential Address	Chesterf. Mid. Count. In.	*Trans. and Proc.*	I.	11	1869
Marshall, W. P.	Modern Railways and Railway Travelling	Birm. Phil. Soc.	*Proc.*	VI.	183	1869
Nelson, D. M.	Proposed Scheme for the Collection, Treatment, and Disposal of the Sewage of Glasgow	Glasgow Phil. Soc ..	"	XX.	311	"
Sang, W.	Some Remarks upon a Steamship Performance Diagram	Liv'pool E. Soc.	*Trans.*	X.	166	"
Saner, J. A.	Flood Gates and Weirs on the River Weaver	" "	"	IX.	17	"
Turner, J. H. T.	Filtration of Sewage	" "	"		26	"
Webster, J. J.	Steam Boiler Explosions	" "	"		41	"
West, H. H.	Steel in the hands of the Naval Architect	" "	"	X.	66	"
Wyld, R. S., jun.	The Laying of Large Mains	" "	"		20	"
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Section H.—ANTHROPOLOGY.

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III.—NOTES OF PAPERS ON THE WORKING OF MINES, METALLURGY, ETC., FROM THE TRANSACTIONS OF FOREIGN SOCIETIES AND FOREIGN PUBLICATIONS.

COAL-MINING IN NOVA SCOTIA.

By E. GILPIN, Jun. *The Colliery Engineer (Scranton, Pennsylvania)*, 1889, *Vol. x., pp.* 3-5, *and three figures.*

In working the Pictou main seam, laying at an angle of 1 in 3, and having a thickness of 38 feet, levels are turned right and left from the pit, and gate-roads are driven uphill at half the angle of the seam every 50 yards. Six bords, 18 feet wide, are turned away as the gateways go up, parallel to the levels, and leaving pillars 8 or 10 yards thick. These bords are 12 to 15 feet high. Rails are laid up the gate-roads and bords, by which the tubs, carrying 12 bushels, are drawn by horses to the faces of the workings and taken down to the level. In working the lower portion of the seam, the same gate-roads are driven level until the bottom of the seam is reached, and then continued as before. The second lift of 15 to 20 feet in thickness is taken out in regular open-cast work, in the old bords already worked in the top section. The pillars are all crushed and lost.

In another mine an incline, 10 feet square, is driven from the level to the full rise of the seam for, say, 450 feet, parallel places being also driven for air-ways at the same time, and of smaller dimensions. Double-way of 2-feet gauge is laid in each "balance," upon one of which a carriage is placed to carry the tubs and a balance tub on the other, connected by ropes to a suitable drum with breaks at the top of the incline. The balances are usually about 150 yards apart. The pillar above the level is left 50 feet thick, and the bords, 15 to 18 feet wide and 12 to 15 feet high, start from the balance and run level; cross-cuts are driven for air at intervals of 60 feet.

Where the angle of the seam exceeds 25 degs. two other systems are in use. In one, the track in the balance is abolished, and the coal tubs are emptied into the balance itself, and the coal runs on the floor or in a shoot of iron sheets, and is filled into tubs on the level by means of spouts. In the second system the bords are driven on the full rise of the seam from the level and a shoot laid in each one.

In the flatter seams the ordinary systems of working are adopted generally.

M. W. B.

A NEW METHOD OF MINING ANTHRACITE.

By W. S. GRESLEY. *The Engineering and Mining Journal (New York)*, 1889, *Vol. xlviii., pp.* 136-140, *and eight figures. Also the Colliery Engineer (Scranton, Pennsylvania)*, 1889, *Vol. x., pp.* 32-35, *and eight figures.*

The new system is that of *longwall withdrawing*, and consists of mining out the entire seam or series of seams of coal or other minerals in one ever-advancing, broad, and continuous face or series of faces, commencing at the most convenient lowest point of the tract to be worked and mining all out upward on the pitch in the direction of the shafts, tunnels, or other openings from the surface. The course or lines of the working faces being kept nearly on the strike, or at right angles to the

dip of each and every seam or bed. Thus as soon as the tract or section of the mine intended to be so worked has been suitably laid out with slopes, air-ways, etc., coal-getting commences all along the line, and on the level course at the deepest or furthest point inside, and in as many seams or splits of the seam as thought desirable. Mining is regularly, quickly, and vigorously carried on, keeping the faces or walls nearly parallel to one another, and of course ascending just as fast as the coal is mined out and removed and the refuse thrown behind. All coal is mined at one operation, each bed or seam being worked a short distance in advance of the upper ones, and no pillars are required to be left. Communications are made between the various seams by cutting away the dividing slates, etc., at the foot of the slope, as well as at the other suitable points inside on either hand. Through these short tunnels or flats, the coal from the back or higher seams is brought out and hoisted along with that cut in the front or lower seam or seams, if several are worked in advance of the flat. M. W. B.

COAL-MEASURES IN THE ARGENTINE REPUBLIC.

La formacion carbonifera de la Republica Argentina. *By* Dr. C. Berg. *Anales de la Sociedad Contifica Argentina,* 1891, *Vol. xxxi., pp.* 209-212, *and Vol. xxxii., pp.* 68-71.

Plant remains were discovered in the coal-mines near Retamito, in the province of San Juan, by Padre Ferd. Meister, and sent by him for determination to Dr. Szajnocha of Cracow. The last-named *savant* referred them to several species of *Lepidodendron, Calamites, Cordaites,* and *Rhacopteris* (Lower Kulm), but he remarked that the specimens were in bad preservation.

The second paper on this subject is chiefly taken up with a discussion of the various claims to priority of the discovery of true Coal-measures in the Argentine Republic. O. S. E.

A GOLD-FIELD IN THE SOUTHERN URALS.

Ein interessantes Goldvorkommen im Südlichen Ural. *By* R. Helmhacker. *Berg- und Huettenmænnische Zeitung,* 1892, *Vol. li., pp.* 95 *and* 96.

The country between the central Ural range and the river of the same name in the Verchnéuralsk and Orsk districts contains, amongst other geological rarities, some curious veins containing gold.

Running in the direction of the mountain range are clefts containing fine-grained diorite, which in their turn are traversed by thin veins of quartz thinly impregnated with gold. The quartz veins are each separated from the diorite by a layer of sandy slate, of about the thickness of stout drawing paper, which appears to be the true home of the gold, and the depth of the gold-bearing stratum is co-extensive with this vein formation.

As in other districts, the occurrence of gold is very irregular, but in places the yield is as much as from ¾ to 1 per cent. In exceptional cases the yield reaches 10 per cent., or even more.

Under a blow from a heavy hammer the diorite at the outcrop will split into thin layers at right angles to the direction of the quartz veins. The diorite blocks thus separated are lifted out, and the parts of them adjacent to the gold-bearing slaty layer are worked in the trough.

A similar stratification was to be seen in the Jilové Mine, on the Sázava, in Bohemia, but the workings are now abandoned, and their yield of gold cannot be ascertained. A. R. L.

BRINE AND NATURAL GAS IN SZE-CHUAN.

Les salines et les puits de feu de la Province du Se-Tchoan. By FATHER LOUIS COLDRE. *Annales des Mines*, 1891, *Series* 8, *Vol. xix.*, *pp.* 441–528, *and Plates xiii–xv.*

At the outset of this paper a *résumé* is given of the Chinese weights, measures, and coinage, with the calculated equivalents of the two former in the metric system. The utility of the *résumé* is apparent when one notes how the units of measurement vary from one province of the Celestial empire to the other.

After a brief mention of the official Great Book, or Yen-fa-che, of the Sze-Chuan salt works, a laborious compilation filling twenty huge tomes, the author sketches the physiography of the region. Sze-Chuan is one of the largest and most mountainous provinces in the Chinese empire. It forms the drainage-area of the upper portion of the Blue River, which flows from west to east through the province. Westward it is shut off from the Thibetan table-land by a range of high peaks covered with eternal snows; northward and eastward it is also barred by great mountain ranges, which are made up of granite, Palæozoic limestone, millstone grit, and Carboniferous and Liassic sandstones. The centre of the province, the least mountainous portion, is made up of Tertiary freshwater sandstones, some of which are hard enough to make good grindstones and paving-stones. Borings have disclosed the presence, immediately beneath the Tertiaries, of Bunter sandstones and marls, and in juxtaposition with this may be placed the fact that the only mineral wealth of this central district of the province is its salt. Politically, the province is divided into four governments, north, south, east, and west—Chuan-pe, Chuan-lan, Chuan-tong, and Chuan-si. In the southern, or Chuan-lan, government are the most extensive salt works and the most abundant wells of natural gas (ho-szin = fire-wells). Altogether, there are about 10,000 brine springs in Sze-Chuan, with a daily yield ranging from an insignificant amount to a really enormous quantity. The total annual salt production is estimated at 812,000 metric tons, value on the spot £5,600,000. By the time the salt reaches the consumer the price is trebled; this is accounted for in part by the heavy Imperial salt-tax and the difficulties of transport.

According to Chinese custom, certain districts have a government monopoly for salt production, but enterprising individuals, who chance to tap brine springs out of the privileged region, sometimes set the monopoly at defiance by wholesale bribery of the government officials. The original possessors of the monopoly have recourse to the same chinking *arguments*, and the mandarins ultimately decide in favour of the party with the longest purse and the most open hand. Contests of this nature are often carried on between town and town.

The author selects for lengthy description the brine springs and evaporating works of the Fu-Shuen district. The borings here are very deep, averaging 2,000 feet, the shallowest being 650 feet, and the deepest, which has proved barren so far, 3,500 feet. The methods of working are very primitive and are characterized by extreme slowness.

It is interesting to note that the most productive brine springs are not tapped, as might be supposed, near the top of the Trias, but low down just above the Carboniferous; whilst, on the other hand, wells of natural gas have been struck before meeting with any coal deposits. In Fu-Shuen this natural gas is used as fuel for the salt-pans, but in other districts wood, straw, and, more rarely, coal, are used.

The author notes the influence of atmospheric changes on the jets of gas from the shallower wells. If the sky is clear and the weather calm the gas jet appears to become more powerful, whilst in misty or windy weather the jet diminishes, or even sometimes stops altogether for a time.

Two of the plates illustrating the paper and representing graphically the various processes of boring, evaporating, etc., were executed by a Chinese draughtsman.

O. S. R.

REPORT ON THE COAL OUTCROPS IN THE SHARIGH VALLEY, BALUCHISTAN.

By W. KING. *Records of the Geological Survey of India*, 1889, *Vol. xxii., pp.* 149-153.

Outcrops of coal are found at Mudgorge Railway Station, Dirgi Station, Khila Hakim Khan, Khost, Hagi Kata, Khila Ali Khan, Sharigh, one good though thin seam, consisting of two layers of coal, the upper 10 inches thick, with band of shale, 2 to 16 inches, and lower coal 16½ inches. M. W. B.

THE CHERRA POONJEE COAL-FIELD IN THE KHASIA HILLS (INDIA).

By TOM D. LA TOUCHE. *Records of the Geological Survey of India*, 1889, *Vol. xxii., pp.* 167-171, *and one plan.*

The coal of Cherra Poonjee occurs near the top of an isolated ridge. A bed of limestone 75 feet thick forms the base of the ridge, and upon it rest several beds of sandstone and shale containing one seam of coal about 10 feet above the limestone.

The seam varies from 3 feet to 9 feet, with a total available quantity of 1,184,269 tons of coal. M. W. B.

THE LAKADONG COAL-FIELD, JAINTIA HILLS (INDIA).

By TOM D. LA TOUCHE. *Records of the Geological Survey of India*, 1890, *Vol. xxiii., pp.* 14-17, *and two plans.*

The Lakadong coal-field is situated on the southern edge of Jaintia Hills. Coal is found near the top of several plateaus.

The Umlotodo plateau contains a seam of coal ranging from *nil* up to 10 feet thick; taking the average section at 2 feet the coal available is about 853,000 tons.

The Umat plateau seam varies up to 4 feet thick, and may contain 311,000 tons of coal.

The coal is very similar to the Cherra. M. W. B.

THE COAL-FIELDS OF LAIRUNGAO, MAOSANDRAM, AND MAOBELARKAR, IN THE KHASI HILLS (INDIA).

By TOM D. LA TOUCHE. *Records of the Geological Survey of India*, 1890, *Vol. xxiii., pp.* 120-124 *and three plans.*

The Lairungao coal-field is situated about 7 miles from Cherra, and the coal is very similar to, but not so good as, that of the Cherra Punji coal-field. Taking the average thickness, there will be about 1,000,000 tons of coal.

The Maosandram coal-field occupies the summit of three small hills. There is one seam attaining a maximum thickness of about 7 feet, but taking the mean thickness there are 63,000 tons available.

The Maobelarkan coal-field is smaller than the last. The Coal-measures appear to have been deposited in a small bay hollowed out of the older quartzites. One seam of coal is found, ranging up to 9 feet thick, containing about 52,000 tons.

M. W. B.

COAL IN NEW CALEDONIA.

Les Mines de Houille de la Nouvelle-Calédonie. By — PORTE. *Le Génie Civil*, 1889, *Vol. xv., pp.* 450, 451.

The first district is rich in coal, which is found at ten places. Near Mont D'Or, coal is found at N'Dé, and Bully Colliery. Two pits are sunk, and at a depth of 60 feet a seam is found about 20 feet thick. The quality is satisfactory, the seam is very regular, and exists over a large area. An anthracite seam is worked at Treizième Colliery. The Sainte-Cécile Colliery, near Portes-de-Fer, is one of the best in the colony, the seam being about 50 feet deep. A smithy coal is wrought at the Tisonier Colliery. Coal is also worked at Brigitte, Karigou, Collignon, Carignan, and Guerrière collieries, and outcrops are found at Boutan, Katiramona, etc.

In the second district coal is less abundant. Rousseau colliery is surrounded with hills containing seams of 3 feet, 2 feet, and 1¼ feet thick. A seam, in two beds, of 5 feet and 2 feet, is found at Aoua. Two pits are sunk at the Loyalty Colliery. Outcrops are found at Me Amélé, Thia and Focola, Dogny, Moméa, etc.

A single outcrop of coal is found at Oua-Té in the third district.

Two outcrops are found in the fourth district, at Koniambo, and Voh, where the seam is over 3 feet thick.

It is considered that the colony should soon supply 12,000 tons per annum, imported from English colonies, and 22,000 tons per annum for steamers, now bought at Sydney.

The mines being near the sea, the coal should not cost more than 12s. 6d. per ton f.o.b., which might be reduced to 10s. per ton. Australian coal is sold for 28s. per ton.

Locality.	Colliery.	Volatile Matter, Water, etc.	Fixed Carbon.	Ash.
Portes-de-Fer	Sainte-Cécile	17·50	77·00	5·50
,, ...	,, ...	16·80	57·20	26·00
Tonghoué	Bruyères	7·00	71·20	21·80
Saint Louis	Treiziéme	8·75	80·00	11·25
,, ...	,, ...	9·70	78·00	12·30
Voh	Thuassoïo	6·50	71·00	22·50
Mont d'Or	Bully	17·00	73·00	10·00
,, ...	,, ...	8·50	78·50	13·00
Paita	Carignan	12·00	74·25	13·75
Koutio-Koueta ...	Brigitte	6·75	80·00	13·25
Moméa		37·50	51·50	11·00
Moindu	Loyalty	20·50	72·00	7·50
,, ...	Huyart	33·50	49·00	17·50
La Foa	Near Me Amélé	10·00	68·00	22·00
Oua-te	Near Mont Panétoni ...	23·50	51·50	25·00
Saint-Vincent	Guerrière	32·00	54·00	14·00
Koe	Collignon	7·25	77·50	15·25
Oua-Poquereux ...	Rousseau	27·00	64·00	9·00
,, ...	,, ...	38·25	54·50	7·25
,, ...	,, ...	28·50	62·00	9·50

M. W. B

THE ANNINA COAL-FIELD IN SOUTHERN HUNGARY.

Das Anninaer Liaskohlen Revier im Banate (Süd Ungarn). ***Glückauf*****, 1891, *Vol. xxvii., pp.* 569-571.**

This coal-field is situated in the Banate, in the county of Kratscho, south-east of Temesvár. Here, above the red sandstone of the Permian, appear coal-bearing Liassic sandstones, overlain by oil shales and thin bands of ironstone. Twelve coal-seams are known, but only four are extensively worked. The main seam varies between 3½ and 12 feet in thickness. The beds are tilted at high angles, and there is much faulting, while in many places the coal has been coked by melaphyre intrusions. The Annina gas and coking coals are the best in Hungary; they are of anthracitic character, and weather very slowly indeed. Mean specific gravity is 1·42; percentage of ash is 3·3 to 7·0; and percentage of carbon is 64·1 to 67·4.

Seven shafts (quadrangular in section, with wooden tubbing) have been sunk in the district to depths varying between 135 and 230 fathoms. Fire-damp is sometimes found in some of the pits, and therefore safety-lamps (Wolf benzine) are used. When the overmen examine the workings for gas they use the Pieler lamp. Four large pumping stations are constantly at work, and ventilators on the Guibal and Pelser system are fitted up at the pits. Between 2,600 and 2,800 work-people are employed, working 12-hour shifts above ground and 8-hour shifts below. No lads under 14 years of age are employed. Villages, stores, hospitals, and schools have been built expressly for the miners; moreover, sick and accident funds and old-age pension funds are contributed to alike by the colliery company and the men.

The coal-production in 1890 amounted to about 270,000 tons.

O. S. E.

THE FIRE-DAMP EXPLOSION AT CAMPAGNAC.

Note sur le coup de grisou survenu à la mine de Campagnac. *By* — **BERNARD.** *Annales des mines,* 1891, *Series* 8, *vol. xix., pp.* 166-214 *and Plate vi.*

The explosion of fire-damp, which occurred at the colliery of Campagnac (Aveyron), at midnight, November 2-3, 1888, cost forty-nine persons their lives.

The coal worked there forms one great mass, striking north and south, dipping 22° west, and attaining a thickness stated at 65 feet. It is disturbed by a longitudinal fault, which forms the roof in the higher part of the workings, and is seen to form a wall at the lower levels.

Fire-damp is abundant in the pit, but irregular in its mode of occurrence. "Damp blowers" are frequent, but "dry blowers" less so. Safety-lamps of the Cosset-Dubrulle type were used throughout the workings, and ventilation was effected by means of a Farcot ventilator, which at about 100 to 110 revolutions forced 800 cubic feet of air through per second. The author gives a detailed account of the salvage operations, which were attended with considerable difficulty. All the bodies were recovered; many were much disfigured and burnt.

In discussing the probable cause of the disaster, he points out that blasting with powder was not practised in the lower levels of the mine; further, that the lamps found near the bodies of the victims showed no traces of having been tampered with.

But it is then shown that the Cosset-Dubrulle lamp, which has a much shorter and wider chimney than the Mueseler type, is untrustworthy in the case of an explosive wave advancing with a rapidity of about 10 feet per second. This lamp

may therefore be regarded as a secondary cause of the disaster: the flame from the lamp set fire to the gases, which burning incompletely left a thick layer of soot on all the surfaces that they travelled over.

Comparative experiments made by M. Bernard with the Cosset-Dubrulle lamp and the Mueseler lamp confirmed his conclusions thus far. As to the primary cause of the disaster, the belief that it was due to an abnormal outburst of fire-damp was confirmed on January 30th, 1889—nearly three months afterwards—by the occurrence, on hewing away the coal at the presumed starting point of the explosion, of an exceptionally violent blower.

Since then, Marsaut lamps alone have been used in the mine, and they are provided with special locks. The French Government have prohibited the use of so-called "bastard Mueseler lamps," to which the Cosset-Dubrulle type may be referred. Shot-firing in the lower levels is stringently forbidden, and is only allowed in the higher levels with special fuzes and safety explosives. The ventilation has been entirely modified, and continuous minute observations are made of the state of the air in all parts of the mine. The regulations altogether have been made more rigorous. O. S. E.

THE EXPLOSION AT LA MACHINE COLLIERY (NIÈVRE).

Note sur l'accident de La Machine (Nièvre). *By* — LAURENT. *Annales des Mines*, 1891, *Series* 8, *vol. xix., pp.* 396-430, *and Plates xi., xii.*

On February 18th, 1890, at about 2·30 p.m., two shots were fired with black powder in the Marguerite Pit. Almost immediately, the men who had fired the shots found themselves surrounded by flames that swept onward through the drift, together with a rush of poisonous gases. Thirty-five men were killed on the spot, and eight more succumbed to the injuries they had received within three days after the accident. In most cases the immediate cause of death was carbon monoxide poisoning.

The La Machine Colliery works the entire coal-field of Decize. In it faults, some of pre-Permian and some of post-Jurassic age, are fairly numerous, and nippings-out are extremely numerous. Since the time when the colliery was started, at the beginning of the present century, no outburst of fire-damp has been recorded there, and there is now accumulated evidence to show that the recent disaster was due to the inflammation of coal-dust.

The dynamical effects of the explosion were small. All that part of the workings where the flames burst out was subsequently found to be coated with very fine dust and soot (though observations previous to the accident had shown that the mine was not a particularly dusty one). On the timber were crusts of coke of varying thickness, and further away from the actual *locus* of the explosion there were more isolated deposits of coke, as if there had been a local recrudescence in the combustion of the coal-dust.

It is believed that one shot was fired before the other. The gases produced by the first one raised a cloud of excessively fine dust from the small coal which covered the floor of the workings, and set fire to the dust. Almost immediately afterwards, the gases from the second shot swept through the mixture of hot air and burning dust, and raised a little farther onward another cloud of coal-dust. The expansion of the gases and the volume of the flames must have been considerably increased by this superposition, as it were, of causes.

The following is an analysis of coal taken from the workings where the accident occurred :—

	Per Cent.	
Carbon	79·65	
Hydrogen...	4·88	
Oxygen	5·58	
Nitrogen	·87	+ 7·91 per cent. of ash.
Sulphur	1·16	
	92·09	

The percentage of volatile matter is 32.

The percentage of volatile matter in the crusts of coke referred to above was found to vary between 13 and 19.

The mine was very dry at the time of the accident. Naked lights were and are used there. Grisoutine B is now used at La Machine for shot-firing instead of powder. O. S. E.

THE COLLIERY EXPLOSION AT POLNISCH-OSTRAU.

Schlagwetter-Explosion am Dreifaltigkeit-Schachte in Polnisch-Ostrau. By JOH. MEYER. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1891, *Vol.* [illegible] *xxxix., pp.* 285-293, 297-302, 311-316, *and* 323-327, *Plate ix.*

At 10·30 a.m., on January 3rd, 1891, at the "Trinity Shaft," Polnisch-Ostrau, a fire-damp explosion took place whereby 61 men lost their lives. This pit belongs to Count Wilczek, and works the lowest seams of the Ostrau-Karwin coal-field. These seams give off on the whole little gas, for the Coal-measures crop out over a large extent of country, and are not overlain, as elsewhere, by impervious shaly beds. Nine seams are worked in the Trinity Pit, by 650 to 680 men—two-thirds working by day shift and one-third by night shift (10 hours). The lowest horizon worked is at a depth of 123 fathoms. Here, the so-called Thick Seam (12·5 feet), the richest of all in gaseous contents, is struck for the third time, and here it was that the explosion arose, probably caused by the misfire of a blasting shot. The coal of the Thick Seam is rather hard in the regularly bedded portions, but elsewhere it is soft and can be easily won without shot-firing. Shots are fired in this seam with Lauer friction fuzes only, and they use what is termed the "hollow loading" system. In all parts of the pit which are free from gas and coal-dust the use of the explosives rhexite and meganite are allowed.

The author proceeds to describe the system of ventilation, and points out that, in one portion of the pit at least, a good deal of ventilating work is cast upon a single air-current, This current was examined at a cross-cut on January 5th; it was passing through at the rate of 14,000 feet per minute, and it contained 19·9 per cent. of oxygen, ·544 per cent. of methane, and ·090 per cent. of carbon dioxide. The observations made point to the conclusion that the ventilation was slightly weaker than usual both before and after the explosion. The barometer was above the average height at that colliery at the time of the explosion, and was actually rising. The annual mean there is 29·213 inches; recorded height on January 3rd, 29·567 inches.

Gas-blowers have not been observed in these workings, and it was maintained that the pit was on the whole too wet to admit of the accumulation of coal-dust; but the author points out that thick layers of dust were observable everywhere after

the catastrophe, and he thinks that the coal-dust cannot have been produced by the explosion. It is significant that the Ostrau Local Committee of the Austrian Fire-damp Commission considered the coal-dust of the Thick Seam the most dangerous of any of the Ostrau seams; but the author also shows that (though undoubtedly marsh-gas and coal-dust were present) from a careful collation of the facts, it is not necessary to assume that they were present in large quantities. For those who are interested in the matter the very lengthy original paper is worth perusal.

O. S. E.

THE BERLIN (1889) MINING EXHIBITION.

Sur quelques appareils employés dans les Mines Allemandes en vue de prévenir les accidents, après les modéles exposé à Berlin en 1889. *By* MAURICE BELLOM. *Annales des Mines*, 1890, *Series* 8, *Vol. xvii., pp.* 329-368, *Plates vii.-x.*

I.—SAFETY-LAMPS.

The Wolf lamp is fitted with an appliance for relighting, consisting in the ignition of a match by a hammer. A later improvement is a knife to cut off the consumed match from the paper roll. A modification of the arrangement is applied to lamps burning heavy oils.

The Wenderoth magnetic lamp-lock consists of two polar plates in the bottom of the lamp and an armature (placed above them), one of whose ends is fixed and the other carries the pin, which acts as a bolt and locks the lamp.

II.—WINDING APPLIANCES.

Schüller Keps.—The Schüller keps consist of four cams fixed loosely on the axles, and which can be fixed in position by means of discs, which are fitted with slots, enclosing the cams. When a cage ascends it presses back and passes the cams, which fall into position and sustain the cage. The discs are then released, and allow the cams to fall and allow the descent of the cage. The discs and cams are then replaced in position for the next cage,

Westmeyer Keps.—The Westmeyer keps are similar to the ordinary ones, except that a series of jointed rods are employed.

Frantz Keps.—Four levers are placed loosely on horizontal axles, of such dimensions that when in their highest or lowest positions they permit the passage of the cage, and will support the cage when fixed in mid-position. The axles supporting the levers are supported upon hydraulic rams and can be moved as required to maintain or release the cage.

Sartorius and Holzer Keps.—These keps are fitted with spiral springs to reduce the shock of the cages upon the keps. The cages are supported upon cams fixed into position by wedges, and when released allow of the descent of the cage.

Haniel and Lueg Keps.—These keps consist of sliding shoes fitted with guide slots, one being horizontal and the other inclined. The inclined groove contains a stud, attached to the arm of a lever. When this is maintained in a horizontal position the shoe will support the cage, and when it is raised upwards it withdraws the shoe and allows of the descent of the cage. The shoes are pressed upward and allow of the ascent of the cage, and fall again into position to support it.

Victoria Safety-gate.—This safety-gate is controlled by means of slotted plates, which cannot be moved when a lever has been raised and the cage is in a certain position, and the cage cannot be moved until the gates are re-closed, owing to the plates engaging into a recess in the side of the cage.

The Pelzer, and Priesmann and Wolf, safety-cages, several safety-gates for inclined planes, Gerhard recording water-gauge, Hipp ventilation recorder, Fleuss respiratory apparatus, and other appliances, are fully described. M. W. B.

DETERMINATION OF THE FLASHING-POINT OF FIRE-DAMP.

Note sur le dosage du grisou par les limites d'inflammabilité. *By* H. LE CHATELIER. *Annales des Mines*, 1891, *Series* 8, *Vol. xix.*, *pp.* 388-395.

The author has verified experimentally the principle upon which the Thomas Shaw fire-damp indicator is based, namely, that the minimum proportion of a gas necessary to form an explosive mixture with air is a strictly definite quantity, accurately ascertainable to within 0·1 per cent. of the total volume. A glass cylinder 1 foot in height and 2½ inches in diameter, narrowing near the base to 1¼ inches (so that it may be closed with the thumb), and surmounted by a glass tube 10 inches long and ¼ inch in diameter, was used for the determinations. The instrument was filled with water and placed over a pneumatic trough of sufficient depth to submerge it completely. A gas, *e.g.*, coal-gas, was introduced into the cylinder, bubble by bubble, by means of a tube of excessively small diameter, and the volume so introduced measured at atmospheric pressure. The testing cylinder was then filled up to a marked point (2 inches above the base) with air; the upper tube is graduated in thousandths of the volume so marked. The instrument, after having been well shaken to promote thorough mixture of the gases, and then replaced for a short time in its original position, was quickly turned, and a lighted match or small gas flame applied. If the mixture was combustible a pale blue flame ran right down the cylinder.

A series of experiments made in this way with coal-gas showed that a minimum volume of 8·1 per cent. forms an explosive mixture with atmospheric air; if the nitrogen in the latter be replaced by oxygen the flashing-point remains practically unaltered, but the presence of carbon dioxide raises the minimum proportion by about ·1 per cent.

The minimum proportion for the former is 6·1 per cent., and for impure carbon monoxide (mixed with 3 per cent. nitrogen) about 16 per cent. The experiments with hydrogen were inconclusive on account of the indistinctness of the flame.

O. S. E.

REPORT OF FRENCH COMMISSION ON THE INFLAMMABILITY OF FIRE-DAMP BY SPARKS PRODUCED BY STEEL TOOLS, AND ON THE EMPLOYMENT OF ELECTRIC LAMPS.

Sur l'Inflammabilité du Grisou par les Etincelles provenant du choc de l'Acier et sur l'emploi des Lampes électriques. Rapport présenté à la Commission chargée de l'étude des explosifs et des lampes de sûreté par la Sous-Commission (MESSRS. MALLARD, LE CHATELIER, *and* CHESNEAU) *désignée par elle pour procéder aux recherches expérimentales. Annales des Mines*, 1890, *Series* 8, *Vol. xviii.*, *pp.* 699-713.

I.—SPARKS PRODUCED BY THE PICK.

Sir H. Davy read a memoir before the Royal Society of London on November, 9th, 1815, in which he gave some particulars respecting the ignition of mixtures of gas and air by electric sparks, and refers to the ignition of fire-damp by

sparks from the steel mill. It is remarked that Sir H. Davy does not state that he had observed ignition caused by sparks from the steel mill. For many years, knowledge of the properties of fire-damp remained stationary.

The French Fire-damp Commission thought it important to continue the researches of Sir H. Davy as to the relation of inflammability of different gases, but not at first to determine the effect of sparks from the shock of steel. On April, 3rd, 1880, M. Roldes communicated to the Société de l'Industrie Minerale the results of experiments as to the safety of methods of lighting shots. In this communication it was erroneously assumed that fire-damp was at least as inflammable as lighting gas, and it was proved that the latter gas could be ignited by sparks from the steel mill.

In consequence of the explosion at Verpilleux in 1889, further experiments were made at St. Etienne by M. Leclère, also with lighting gas, sparks being produced by striking with a pick on fragments of hard stone and nodules of ironstone, and ignition of the lighting gas ensued.

The question of the ignition of fire-damp remained untouched because it is not possible to draw conclusions respecting the ignition of fire-damp from lighting gas The experimental sub-committee took up the question and made experiments both with lighting gas and chemically prepared marsh-gas. Sparks were produced in contact with inflammable mixtures of these gases by striking with a pick on hard stones, particularly on the porphyry used for paving in Paris. With lighting gas the sparks caused ignition at nearly every blow. When marsh-gas was used ignition never occurred. With mixtures of ¾ marsh-gas and ¼ lighting gas by volume no ignition was effected. It required equal volumes of marsh-gas and lighting gas before ignition could be caused. These experiments (often repeated) are held to demonstrate that in order that mixtures of air and fire-damp may be ignited by sparks from a pick, it is necessary for the fire-damp to contain, beyond the marsh-gas, a proportion of hydrogen or hydrocarbons incomparably higher than has ever been been found by analysis. The sub-committee afterwards made further experiments with marsh-gas and also with fire-damp obtained from the workings of a colliery. Sparks were produced by a mechanical drill and hard stone. Inflammation was not produced either with marsh-gas or fire-damp. Further experiments were made with sparks produced by pressing a bar of steel against a rapidly revolving emery wheel. The sparks formed a dazzling and continuous shower. A very large jet of an inflammable mixture of air and marsh-gas or air and fire-damp was directed in various manners into the sparks without causing ignition.

M. Leclère also afterwards repeated his experiments and used fire-damp from the Grand-Treuil pit. Sparks were produced by a heavy pick (weighted) from pyrites and carbonate of iron without causing ignition. It appears therefore the sparks produced by the shock of steel, and especially by the miner's pick, on hard stones, are incapable of igniting explosive mixtures of fire-damp and air.

II.—Electric Lamps.

Records showing the lighting power of the Stella and Pollack lamps are given. The Stella lamp gave an effective light, varying from 0·25 to 0·16 candle-power at the end of the eighth hour. The Pollack lamp gave an effective light, varying from 0·37 to 0·25 candle-power at the end of the sixth hour. Experiments made with the filaments of electric lamps, such as are proposed for use in mines, showed that when broken in inflammable currents of air and lighting gas or air and marsh gas they were capable of causing ignition of the mixtures. Other experiments showed that electric sparks produced by the opening or closing of the current in

portable electric lamps did not ignite explosive mixtures. The conclusion arrived at is that in portable electric lamps the only danger is from the breakage of the glass surrounding the incandescent carbon thread, and that this danger can be effectively guarded against by enclosing the filament with a strong outer glass. It is still doubtful whether portable lamps as at present constructed do not deteriorate too rapidly to permit of their general use. It will be necessary to find a method for indicating fire-damp. It is thought that the Liveing indicator may be used with a lamp. W. N. A.

EXPERIMENTS IN SEDIMENTATION.

Expériences sur la sédimentation. *By* Prof. J. THOULET. *Annales des Mines*, 1891, *Series* 8, *Vol. xix.*, *pp.* 5-35 *and Plate i.*

In the experiments described in this paper the author made use of the purest obtainable white kaolin of Limoges. A graduated tube containing 60 cubic centimetres of water with a known quantity of the kaolin in suspension, was taken, a drop of water saturated with sodium chloride introduced into it, the tube then sealed and suspended in a d'Arsonval oven kept at a temperature of 56·5 degs. Cent. (= 133·7 Fahr.), and the time of descent of the particles of kaolin measured by noting at stated intervals the height of the clear portion of the solution. The results tended to prove that the rate of fall is uniform.

Another series of experiments was made at varying temperatures, the results showing that the higher the temperature the more rapid was the fall of sediment. At 23 degs. Cent. (= 73 degs. Fahr.) and below the particles of kaolin remained indefinitely in suspension.

Further experiments were conducted, in which the quantity of kaolin was made to vary, in which hydrochloric acid and sea water were severally introduced into the solutions, and in which the effects of pressure and of the dissolved air were studied. Finally, the rate of fall of foraminiferal tests in sea water was measured. The foraminifera were divided into five classes according to their diameter, and it was found that to fall 6,000 feet they took from 13½ to 73½ hours, according as they measured ·12 to ·75 mm. ($\frac{1}{210}$ to $\frac{1}{3}$ inch).

The author mentions that he spent more than three years over the above experiments, and he summarizes his conclusions as follows:—

1. Particles immersed in water fall at a generally uniform rate, with a rapidity which increases in the same ratio as the difference of density between solid and liquid, and which diminishes when the temperature approaches that at which the co-efficient of expansion of distilled water is equal to the co-efficient of the particles.

2. Up to 12 atmospheres or thereabouts pressure appears to exercise no influence.

3. The dissolved air forms a sort of sheath adhering to the surfaces of the particles. (This helps to account for the oxygenation, and hence for the habitability, of the abysmal depths of the ocean.)

4. Precipitation of clay appears to follow exactly the same course in fresh water mixed with 10 per cent. of sea water, as in pure sea water.

5. Foraminifera fall quickly to the sea bottom, and since the dissolving power of sea water is insignificant at ordinary pressures, they lose little in weight during the descent.

6. The phenomenon of "clouds" or multiple superposed strata, formed by very fine dusts falling through a liquid, is attributable to simple mechanical causes, and is only observed in the case of liquids contained in vessels of small capacity.

O. S. E.

INDEX TO VOL. II.

EXPLANATIONS.

The — at the beginning of a line denotes the repetition of a word; in the case of Names, it includes both the Christian Name and Surname.

Discussions are printed in *italics*.

The following contractions are used:—

C. and M.C.: Chesterfield and Midland Counties Institution of Engineers.

M.: Midland Institute of Mining, Civil and Mechanical Engineers.

N.E.: North of England Institute of Mining and Mechanical Engineers.

S.S.: South Staffordshire and East Worcestershire Institute of Mining Engineers.

Abbontuyakoon, 83.
— gold-mine, 75, 77.
ABEL, Sir F., quoted, 378, 380.
Abosso gold-mine, 73, 76, 77, 83, 84.
Abstracts of papers from foreign publications, 577.
Accidents, fatal and non-fatal in New South Wales, 288-290.
— from overwinding, prevention of, 243.
Accra, 77.
ACHARD, M., quoted, 196.
ADAMSON, S. A., geological photography, 565.
Adjah Bippoh gold-mine, 75, 76, 77, 83.
Advertizement, ii.
Africa, West, 69.
African Gold Coast Company, 83.
Agricultural implements, improvements in, 252.
Ahantah gold-mines, 82.
Air, composition of, 388.
—, compressed, 192.
— saturated with coal-dust, explosives fired into, 419.
Akankoo, 78, 84.
ALFORD, C. J., quoted, 69, 74, 77.
Alfreton, Teversal, and Pleasley collieries, invitation to visit, 495.
ALLAN, JOHN, prize awarded to, 472.
ALSOP, S., vice-president, election, C. and M.C., 209, 524.
Amalgamation of gold as carried on at Abosso, 78.
Ambulance, St. John's, 5.
Ammonite, 51, 53.
—, experiments with, 489.
Annina coal-field in Southern Hungary, 582.
Analysis and composition of roburite, 396.
— — — — tonite, 397.
— of Australasian coals, 322.
— — Buller coals, 324.
— — Bulli seam, 277, 278.
— — coal-dust, 417, 418.
— — colliery explosions in 1888, 1889, 1890, 140.
— — fumes, 380.
— — Green Island coal, 326.
— — Greta coals, 324.
— — Greymouth coals, 324.
— — Kaitangata coal, 325.
— — Kawa Kawa coals, 325.
— — Lake Macquarrie coal, 325.
— — Malvern Hills coal, 326.
— — Mountain coal, 325.
— — Newcastle coals, 324.
— — New South Wales coals, 324-326.
— — New Zealand coals, 324-326.
— — Queensland coal, 325, 336.
— — Shag Point coal, New Zealand, 325.
— — Silver Hill coke, 551.
— — Tasmanian coals, 325.
— — Waikato coal, 326.
— — Whangarei coals, 326.
Ancient remains, catalogues of, 564.
Ancobra river, 70, 77, 82, 83, 84.
ANDREWS, GEORGE MURRAY, election, N.E., 48.
Andrews House collieries, electric motors at, 160, 161.
ANDREWS, THOS., *coal-field adjoining Barnsley*, 107.
—, *on the action of tidal streams on metals*, 110.
Annesley colliery, 25, 42.

Anthracite, a new method of mining, 577.
Anvil creek colliery, 273.
Aodowo, 83.
Apparatus, experiments with carbonite, 85.
— for prevention of overwinding, 124, 144.
— — — — winding and overwinding accidents at collieries and blast furnaces, 243.—Discussion, 246.
—, safety, for cages, 362.
Appim, 77.
Armstrong, H., member of council, election, N.E., 493.
Armstrong, Lord, past-president, N.E., 493.
—, quoted, 181, 182.
Armstrong, Wm., member of council, election, 482.
—, vice-president, election, N.E., 493.
Armstrong, W., Jun., *experiments with carbonite*, 88.
—, fumes committee, 368.
—, member of council, election, 47, 482.
—, member of council, election, N.E., 493.
—, prize awarded to, 472.
—, quoted, 351.
Argentine Republic, coal-measures in, 578.
Ashworth, James, quoted, 352.
—, *detection of fire-damp*, 352.
Asquith, T. W., member of council, election, N.E., 493.
Assim, 82.
Atkinson, J. J., quoted, 484.
Atkinson, J. B. and W. N., quoted, 417, 426.
Atkinson, W. N., *coal-dust*, 423.
—, *investigation of fumes*, 412, 414.
Australasia, the coal-fields of, 321.
Australia, physical structure and geology of, 299.
Australian Coke Company, quantity and value of coke manufactured by, New South Wales, 285.
— Company's Sea colliery, 274.
Awards for papers, N.E., 471.
Axim, 70, 76, 77, 81.
Ayton, Ernest F., nomination, 456, election, N.E., 470.
Ayton, Henry, *electric mining safety-lamp*, 92.
—, prize awarded to, 472.
—, *Waddle (1890) fan*, 177.

Babbington, 24, 25.
Bagot, A., quoted, 499.
Bailes, T., *North Fenham colliery*, 68.
Bailey, E. J., election, S.S., 116.
Bainbridge, Emerson, *coal-fields of Australasia*, 340.
—, *Elsom improved method of lighting miners' safety-lamps*, 36, 37, 62.
Bainbridge, Emerson, *experiments with Capell and Schiele fans*, 225.
—, — — *explosives*, 56.
—, quoted, 235.
—, visit to Nunnery colliery, 215.
Balfour, Arthur, quoted, 68.
Baltimore Coal Company's colliery, 280.
— coal-measures, 280.
— coal-seam, 280.
Baluchistan, coal outcrops in Sharigh Valley, 580.
Banket deposits of the Gold Coast, West Africa, 69.—Topography, 70.—Taquah mine, 71.—Abosso mine, 73.—Adjah Bippo mine, 75.—Cinnamon mine, 75.—Crockerville mine, 75.—Abbontuyakoon mine, 75.—Effuenta mine, 75.—Teberibi mine, 75.—Geological notes, 76.—Mode of working, 78.—Amalgamation, 78.—Labour power and fuel used, 80.—Leases, 80.—Machinery, 81.—Cost of working, 81.—Production, 81.—Climate, 81.—History, 82.—Addendum, 83.
— reef, 69.
Barbot, John, quoted, 82.
Barnes, Alfred Thomas Holland, election, C. and M.C., 46.
Barnes, Arthur Gorell, election, C. and M.C., 46.
—, *experiments with Capell and Schiele fans*, 224, 225, 229.
Barnsley, coal-field adjoining, 7-9.—Discussion, 105.
— thick coal, 24, 106.
Barometer and thermometer as applied to mining, 496.—Discussion, 500.
—, thermometer, &c., readings, 1890, 556.
Barrett, C. R., *experiments with carbonite*, 88.
Barrow Coal Company, 7.
Barrowby, 29.
Barwood colliery, explosion at, 137.
Basford gas works, visit to, 41.
Batteries, portable electric, 444.
Bayldon, D. H., prize awarded to, 472.
Beattie-Scott, W., *geological sketch of the town and district of Nottingham*, 27.
Beds, bending of, near veins, 64-67.—Discussion, 68.
Bedson, Dr. P. P., *coal-dust*, 422.
—, *experiments with carbonite*, 87, 89.
—, fumes committee, 368.—Report on the chemical examination of the fumes of roburite and tonite in mines, 369.—Joint statement of conclusions and recommendations, 388.—Discussion, 413, 467, 468.
—, prize awarded to, 472.
Belgrami, Seyd Ali, nomination, 171; election, N.E., 179.

BELL, SIR LOWTHIAN, member of council, election, 47, 482.
—, past-president, N.E., 493.
—, quoted, 28.
BELL, THOS., *bending of beds near veins*, 68.
—, *centrifugal ventilating machines*, 488.
—, *election of officers*, N.E., 494.
—, *experiments with carbonite*, 88, 90, 91.
—, fumes committee, 368.
—, *pumping appliances at Eltringham colliery*, 465, 466.
Bellambi colliery, 276.
Bellite, 51, 53.
BELLOM, MAURICE, Berlin (1889) mining exhibition, 585.
Belts, screens, &c., at Pleasley colliery, 536.
— — — at Teversal colliery, 541.
— — —, at Silver Hill colliery, 550.
Belvoir castle, 29, 45.
— hills, 29.
— inn, luncheon at, 45.
Bending of beds near veins, 64.—Discussion, 68.
BENSON, T. W., member of council, election, N.E., 493.
—, *Waddle* (1890) *fan*, 178.
BENTON, GEORGE, election, C. and M.C., 46.
BENTON, W. E., election, M., 447.
BERG, Dr. C., coal-measures in the Argentine Republic, 578.
BERKLEY, C., vice-president, election N.E , 493.
Berlin (1889) mining exhibition.—I. safety-lamps.—II. winding appliances, 585.
BERNARD, —., fire-damp explosion at Campagnac, 582.
Berrima, 278.
Bestwood colliery, 25.—Visited, 44.
— pumping station, 44.
BETLEY, RALPH, analyses of coal-dust, 417, 418.
BEWICK, Jos., quoted, 28.
BEWICK, T. J., member of council, election, 482.
—, retiring vice-president, N.E., 493.
BIGGE, D. SELBY, nomination, 180; election, N.E., 455.
BIGGE, EDWARD ELLISON, nomination, 456; election, N.E., 470.
BINNS, G. J., election, C. and M.C., 214.
—, prize awarded to, 471.
—, *coal-fields of Australasia*, 340.
BIRAM, —, first ventilating fan erected by, 256.
Birch Coppice colliery, 100, 101.
BIRD, W. J., prize awarded to, 472.
Birmingham Central Tramways Company.—Electrical tramway depôt, 127.—Cable tramway depôt, 131.
— electrical charging station, Bournbrook, 19.—Cable depôt, Hockley, 20.
BISHOP OF DURHAM, quoted, 165.
BITZOS, NICHOLAS JOHN, nomination, 63; election, N.E., 171.
BIVER, M., quoted, 199.
BLACKETT, W. C., *coal-dust*, 424, 429.
—, *experiments with explosives*, 56, 60.
—, *pumping appliances at Eltringham colliery*, 465.
—, *safety apparatus for cages*, 366.
—, *steam loop*, 147.
—, *Waddle (1890) fan*, 178.
Black shale cannel, tests with, 532.
— — seam, 24, 531; section, 532.
Blast-furnaces, prevention of accidents from overwinding at, 243.
Blasting, 122.
— gelatine, 51, 54.
— powder, compressed, 51, 53.
— — experiments with, at Haswell, 406, 407.—South Hetton, 409.
Blown out shots, 32.
Blue Mountains, section, 322.
Boghead mineral raised, in New South Wales, 285.
Boiler tests at Eltringham colliery, 458.
Boilers at Pleasley colliery, 533.
— — Silver Hill colliery, 547.
— — Teversal colliery, 544.
—, economical use of steam in, 344.
—, evaporative efficiency of, 345.
Bottom soft seam, 24.
BONNAT, J., quoted, 70, 77, 82, 83.
Bonsa River, 70.
BONSON and WALKER, quoted, 70, 71.
BONSER, EDWD., *explosives used in mines*, 492.
Borehole at Holt-Sutherland, 271.
— coal-seam, New South Wales, section, 274, 275, 306.
Borrowash, 523.
BONNEY, PROF., geological photography, 565.
Borswick Burn, 68.
BOSMAN, WILLIAM, quoted, 182.
Botany, borehole, depth, 329.
Bothwell Park colliery, explosion at, 137.
Bottom hard seam, 24, 25.
Boulders, erratic, 563.
Bowers separator, 3.
BOYD, E. F., memoir of, 204.
—, quoted, 187.
BOYD, HUGH F., memoir of E. F. Boyd, 204.
BOYD, R. F., member of council, election, 482.
— member of council, election, N.E., 493.
— *vote of thanks to Institution of Civil Engineers*, 431.
BRADFORD, GEORGE, election, N.E., 48.
BRAMWELL, HUGH, prize awarded to, 472.
BRAMWELL, Sir F., quoted, 182.

Brancepeth colliery, coal-dust explosion at, 138, 427.
Branxton, 280.
Breakfast Creek, Penrith borehole, depth, 329.
Breckon, J. R., *locked coil wire ropes*, 266, 267.
Brine and natural gas in Sze-Chuan, 579.
Bristol improved portable electric safety-lamp. 443, 446.
British association for the advancement of science: report of the corresponding societies committee, 563.
Brockwell seam, section of strata below, 457.
Broomhill colliery, steam loop at, 146, 147.
Brough, Bennet H., prize awarded to, 472.
Brown, E., *electrical energy*, 157, 160.
Brown, M. Walton, appointed secretary *pro tem.*, 103; appointed secretary. 249
—, appointed secretary, N.E., 455.
—, barometer, thermometer, &c., readings, 1890, 556.
—, *coal-dust*, 427.
—, *detection of fire-damp*, 357, 358.
—, engineer to fumes committee, 368.
—, experiments with explosives used in mines, 49.—Discussion, 56, 488.
—, member of council, election, 47, 482.
—, prizes awarded to, 471, 472.
—, quoted, 56, 57, 60, 352, 527.
—, report on experiments with explosives, 398.
—, *S.C.P. miner's electric safety-lamp*, 40.
—, Waddle (1890) fan, 173.—Discussion, 175.
Brown, M. Walton, and Wm Foggin, experiments with carbonite, 85—Discussions, 87, 488.
Browne, Coroner, quoted, 526.
Browne, Hugh, *explosives used in mines*, 527.
—, *geological sketch of the town and district of Nottingham*, 523.
Brunner coal-field, 332.
Brynmally colliery, explosion at, 138.
Buddle, John, quoted, 165, 167, 168, 255.
Bull's hosiery manufactory, 41.
Buller coal-field, 331.
— — —, analyses of coals, 324.
Bulli colliery, New South Wales, 278.
— —, rates for hewing, &c., 317.
— company, quantity and value of coke manufactured in New South Wales, 285.
— seam, 272, 276, 277, 278.
Benedick, W. de L., quoted, 84.
Bunning, C. Z., prize awarded to, 472.
Bunning, T. W., quoted, 207.
Burn, James, nomination, 48; election, N.E., 63.
Burns, David, *experiments with carbonite*, 89.
—, on the bending of beds near veins, 64.—Discussion, 67.
—, prize awarded to, 472.
Burton, R. F., quoted, 69, 70, 83.
Bye-laws of the Federated Institution of Mining Engineers, x.

Cable Tramway depôt, Birmingham Central Tramways Company, 20, 131.
Cage guides, invention of, 255.
— props, 97.
Cages and tubs at Pleasley colliery, 533.
—, safety apparatus for, 362.
Cameron, V. L., quoted, 69, 70, 76, 83.
Campagnac, fire-damp explosion at, 582.
Campbell, W. G., quoted, 73.
Cannel coal, petroleum oil. output in New South Wales, 285—Value, 285.
— —, Pleasley, Silver Hill, and Teversal, 532.
Cape Coast Castle, 77.
Capell double inlet fan at Silver Hill colliery, experiments with, 549.
— fan, experiments with.—Discussion, 216.
Capell, G. M., *experiments with Capell and Schiele fans*, 218, 220, 228.
Carbonite, 51, 53, 54.
—, experiments with, 85.—Discussions, 87, 488.
Carbon monoxide, production of, 384.
Carnes, Charles Spearman, nomination, 456; election, N.E., 470.
Carr, William Cochrane, election, N.E., 48.
Carrington, Thos., *dinner at Sheffield*, 234.
—, member of council, election, 452.
Carroll purifier, 3, 239.
Cassel Gold Extracting Company, 84.
Cassop, 68.
Castle colliery, Cyfarthfa, locked coil wire ropes at, 263.
Catharine Hill Bay, 272.
Cathcart, Peto, and Ratford's electric safety-lamps, 446.
Cattermole, A. E., election, S.S., 241.
Caythorpe, 29.
Centrifugal ventilating machines, 483.
Chama, 70.
Chambers, W. Henry, *coal-field adjoining Barnsley*, 106, 107, 108.
—, *joint meeting and excursion*, 104.
—, member of council, election, M., 452.
Chatelier, H. Le, determination of the flashing-point of fire-damp, 586.
—, report of French commission on the inflammability of fire-damp, &c., 586.
Chell colliery, explosion at, 139.
Chemical examination of the fumes from explosives, 388.

Cherra Poonjee coal-field in the Khasia Hills (India), 580.
CHESNEAU, —., report of French commission on the inflammability of fire-damp, 586.
CHESTER, P. M., scrutineer, C. and M.C., 524.
Chesterfield and Midland Counties Institution of Engineers: list of papers read, 250.
Cinderhill colliery, 25.—Visited, 44.
Cinnamon Bippoh mine, 75.
City and South London Railway, 434.
CLANNY, Dr., quoted, 165.
CLARK, THOS., election, N.E., 48.
CLARK, W. F., *old mining implements*, 136.
—, vice-president, election, S.S., 116.
CLARKE, E. B., *on the Stauss system of colliery cage props*, 97,
CLARKE, T. B. A., election, M., 448.
Clay Cross colliery, 24.
Clifton colliery, 23, 25, 43.
Climate of the Gold Coast, 81.
Clip-sheave, 194, 195.
CLOWES, Prof., detection of fire-damp, 352.
Coal analysis, 277, 278.
—, average value per ton of coal exported from New South Wales, 282.
— Cliff Company, 276.
— —, New South Wales, 271.
— consumed in New South Wales, 282.
— cutting machine, 123.
Coal-dust commission, appointment of members of the South Staffordshire Institute to give evidence before, 241.
— —, details of experiments with various explosives fired into air saturated with coal-dust.—Series No. 1: without tamping, 419.—Series No. 2: coal-dust tamping, 419.—Series No. 3: clay tamping, 419.—Series No. 1: without tamping or dust in suspension, 420.—Series No. 2: coal-dust tamping and dust in suspension, 420.—Series No. 3: clay tamping and dust in suspension, 420.—Discussion, 421.
Coal exported from New South Wales, 282.
— exports from Newcastle, New South Wales, 291.
Coal-field adjoining Barnsley, 7.—Discussion, 9, 105.
— —, Annina, in Southern Hungary, 582.
— —, Buller, 331-332.—Analyses of coals, 324.
— —, Cherra Poonjee, in the Khasia Hills (India), 580.
— —, Green Island, 338.—Analyses of coals, 326.
— —, Greta, 333.—Analyses of coals, 324.
Coal-field, Greymouth, 332.—Analyses of coals, 324.
— —, Illawara, 335.—Analyses of coals, 325.
— —, Kaitangata, 337.—Analyses of coals, 325.
— —, Kawa Kawa, 334.
— —, Lakadong, Jaintia Hills (India), 580.
— —, Lake Macquarrie, 335.
— —, Malvern Hills, 338.—Analyses of coals, 326.
— —, Mountain, 336.—Analyses of coals, 325.
— —, Newcastle, New South Wales, 333, 335.—Analyses of coals, 324.—Sections of strata, 303.
— —, Northumberland and Durham, output and duration, 181, 182.
— —, Nottinghamshire, 22.
— —, Shag point, 337.—Analyses of coals, 325.
— —, Waikato, 338.—Analyses of coals, 326.
— —, Whangarei, 337.—Analyses of coals, 326.
— —, Yorkshire, 16.
Coal-fields of New South Wales, 333, 335, 336.
— —, New Zealand, 331, 332, 334, 337, 338.
— — of Australasia, 321.—Geological, 321.—Table of analyses of Australian coals, 324.—Tabular statement of coal-measures in Newcastle district, New South Wales, 327.—Buller coal-field, New Zealand, 331.—Brunner coal-field, New Zealand, 332.—Newcastle and Greta coal-fields, New South Wales, 333.—Kawa Kawa coal-field, New Zealand, 334.—Lake Macquarrie coal-field, New South Wales, 335.—Illawara coal-field, New South Wales, 335.—Mountain coal-field, New South Wales, 336.—Queensland coal-fields, 336.—Tasmanian coal-fields, 336.—Kaitangata coal-field, New Zealand, 337.—Shag point coal-field, New Zealand, 337.—Whangarei coal-field, New Zealand, 337.—Malvern Hills coal-field, New Zealand, 338.—Waikato coal-field, New Zealand, 338.—Green Island coal-field, New Zealand, 338.—Conclusions, 339.—Discussion, 340.
— — Lairungao, Maosandram and Maobelarkar (India) 580.
— — New South Wales, 268-321.—Discussion, 340.
— —, Queensland, 336.—Analyses of coals, 325.
— —, Tasmanian, 336.—Analyses of coals, 325.
Coal-getting by machinery.—Discussion, 230-234.

Coal in New Caledonia, 565.
— *lowering arrangements at Cramlington colliery*, 93.
— measures in Newcastle district, New South Wales, tabular statement of, 327.
— — — the Argentine Republic, 578.
— mining in Nova Scotia, 277.
— output in New South Wales, 281, 283-286.
— — — Northumberland and Durham, 181, 182.
— outcrops in the Sharigh Valley, Baluchistan, 580.
—, Pennsylvanian, at Hamburg, 235.
— raised per person employed in New South Wales, 287.
Coals, analyses of, 324-326.
Coal-seam sections in New South Wales, 273.
— trade of Yorkshire, 1872-89, 5.
Coast erosion, 565.
COCHRANE, HENRY HEATH, nomination, N.E., 471.
COCHRANE, WM., *coal-dust*, 429.
—, *economical use of steam in colliery engines*, 351.
—, *election of officers, N.E.*, 494.
—, *explosives used in mines*, 492.
—, *fire-damp detector*, 488.
—, *investigation of fumes*, 412, 468.
—, *London meeting*, 259.
—, member of council, election, 47, 482.
—, on a duplex arrangement of centrifugal ventilating machines, 483.
—, past-president, N.E., 493.
—, presidential address, N.E., 181.
—, *pumping appliances at Eltringham colliery*, 464, 466.
—, *safety apparatus for cages*, 366.
—, *transmission of power*, 263.
Cockle Creek, New South Wales, section, 307.
COGHLAN, —, boring by, 329.
COKE, G. E., member of council, election, 511.
—, *technical education*, 98, 99.
—, vice-president, election, C. and M.C., 524.
Coke exports from Newcastle, New South Wales, 291.
—, manufacture in New South Wales, 281.
ovens at Silver Hill Colliery, 550.
— — — Teversal colliery, 544.
—, quantity manufactured in New South Wales, 285—Value, 285.
Collieries, prevention of accidents from overwinding at, 243.
— under inspection in New South Wales, 281.
— visited by members of the Federated Institution of Mining Engineers, 41, 169, 170.
Colliery accidents, the formation of a society in Sunderland for the prevention of, 165.
— depreciation, 211.
— engines, economical use of steam in, 344.
— explosion at La Machine (Nièvre), 583.
— — — Peinisch Ostrau, 564.
— explosions, 242.
— manager, duties of, 124.
— managers' association, 5.
Compressed air, 192.
— blasting powder, 51, 53.
Comstock lode, 196.
Contents, iii.
Corresponding societies of the British Association for 1889-90, 566-576.
Cost of working gold mines on the Gold Coast, 81.
COTTERELL, O. J., election, C. and M.C., 214.
Council, election, C. and M.C., 525.
— —, M., 452.
— —, N.E., 493.
— —, S.S., 116.
— of the Federated Institution, xvii.
— — — — —, election, N.E., 482.
— — — — — election, C. and M.C., 511.
Council's report, 249.
— —, C. and M.C., 504.
— —, M., 448.
— —, N.E., 473.
— —, S.S., 113.
COWEN, JOSEPH, quoted, 297.
COX, Dr. JAMES, quoted, 329.
COX, S. HERBERT, the coal-fields of Australasia, 321.—Discussion, 340.
CRAWFORD, W., fumes committee, 368.
CRIGHTON, J., *experiments with Capell and Schiele fans*, 216, 227.
Crockerville gold-mine, 75, 81, 83.
CROUDACE, T., quoted, 293, 294.
Crow coal-seam, 457.
CURLEY, —, quoted, 295.
CURR, JOHN, inventor of shaft or cage guides, 255.
CURTIS, J. S., quoted, 69, 76, 77.
Cuvelier lock for safety-lamps, 444.
Cwmbran colliery, explosion at, 139.
Cyfarthfa, locked-coil wire ropes at, 263.
Cymmer collieries, experiments with explosives at, 49, 85.

DAGLISH, JOHN, member of council, election, 47, 482.
— past-president, N.E., 493.
DAHSE, PAUL, quoted, 69, 70, 71, 83.
DALE, DAVID, member of council, election, 482.
Darley main colliery, 7, 105.
DAVEY, HENRY, quoted, 199.
DAVEY, Sir HUMPHREY, 165.
DAVID, T. W. E., quoted, 330.

DAVIES, W., member of council, nomination, 209; election, C. and M.C., 525.
DAVIS and SONS, electric light fittings, exhibition of, 134.
DAVIS and STOKES, quoted, 161.
— — — safety commutator, 233.
DAVIS, HENRY, *distribution of electrical energy*, 95, 96.
— quoted, 96.
DAWBURN, ARTHUR GREY, election, C. and M.C., 511.
DAWKINS, Prof. BOYD, geological photography, 565.
DAY, JOHN HY., election, C. and M.C., 214.
Day house colliery, 107.
DEACON, M., *coal-getting by machinery*, 233.
—, comparative experiments upon a Capell and a Schiele fan working under similar conditions.—Discussion, 216-230.
—, member of council, election, C. and M.C., 525.
DEAN, EDWARD, quoted, 78.
Dean Lane colliery, explosion at, 139.
Deep hard seam, thickness, 532.
De Kaap, 69, 74, 76, 77.
DENNIS, HENRY, election, S.S., 116.
Denton, 29.
DEPLEDGE, A. M., scrutineer, M., 448.
DE RANCE, geological photography, 565.
—, underground waters, 564.
Detection of fire-damp, remarks on safety-lamps, 352.—Tests made on safety-lamps, 355.—Discussion, 357.
Determination of the flashing-point of fire-damp, 586.
DIAMOND, JAMES, election, C. and M.C., 46.
Diamond or dirty seam, 275.
DICKENSON, C., election, M., 1.
DICKINSON, G. W., election, C. and M.C., 209.
Dinkara gold mine, 82.
Dinner at the Royal Victoria Hotel, Sheffield, 234.
— in the New Assembly Rooms, Newcastle-upon-Tyne, 164.
Dipton colliery, explosion at, 138.
Disappearance of native plants, 566.
Distribution of electrical energy over extended areas in mines.—Discussions, 94, 149, 164.
DIXON, —., analyses of Australasian coals, 325.
Dixon, Prof. H., quoted, 412.
Dodworth colliery, 107.
Dora Creek borehole, 329.
DORSAY, E. B., quoted. 69.
DOUGLAS, DAVID, nomination, 456; election, N.E., 470.
DOUGLAS, THOS., member of council, election, 47, 482.
—, vice-president, election, N.E., 493.
DRUMMOND, Dr. D., fumes committee, 368.—Report on the effects produced by the fumes of explosives, 385.—Joint statement of conclusions and recommendations, 388.
DUKE OF NORFOLK'S collieries, guides first used at, 255.
— — NORTHUMBERLAND, quoted, 165.
Dunsil seam, 532.
Duplex arrangement of centrifugal ventilating machines, 483.—Discussion, 486.
DUPREZ, M., quoted, 196.
Durham and Northumberland coal-fields, output and duration, 182.
DURHAM, Bishop of, quoted, 165.
Durham Coal Owners' Association, investigation as to whether the fumes produced from the use of roburite and tonite in coal mines are injurious to health, 368.
— colliery, New South Wales, No. 1 pit section, 304.
— district, explosions in, 138.
— Miners' Association, investigation as to whether the fumes produced from the use of roburite and tonite in coal mines are injurious to health, 368.

EAMES, WM., election, C. and M.C., 214.
Earth tremors, 564.
Eastcroft gas works, 41.
East Howle colliery, Capell fan at, 226.
EASTWOOD, E., treasurer, C. and M.C., 525.
Eaton, 29.
Economical use of steam in colliery engines, 344.—Evaporative efficiency of boilers, 345.—Experiments upon a triple-expansion engine, 347.—Discussion, 351.
EDISON, —., quoted, 95.
Education, technical, 97.
Edwalton, 23.
Effuenta, 75, 76, 83.
Eight hours from bank to bank, 4.
ELCE, JAS., election, M., 448.
Electric and underground haulage at Pleasley colliery, 537, 541.
— lamps, employment of, 587.
— —, Pitkin portable batteries for, 444.
— mining and other portable lamps, 446.
— — safety-lamp, 92.
— light fittings, exhibition of, 134.
— Lighting Company's station, Newcastle and district, visit to, 170.
— Power and Traction Company, Limited, General, 439.
— safety-lamp, Bristöl, 443.
— — —, the S.C.P., 38, 529.
—Supply Company's station, Newcastle-upon-Tyne, visit to, 170.
— — Corporation, Limited, London, 439.
Electrical charging station, Birmingham Central Tramways, 19.

Electrical safety apparatus for cages, 362.—Discussion, 366.
— transmission of power, 191, 202.
— energy.—Discussion, 94.
— Tramway Depôt, Birmingham Central Tramways Company, 127.
Electricity, 186, 254.
Elsmore colliery, chemical examination of fumes of explosives at, 368.
— —, experiments with explosives at, 368, 369, 373, 376, 381, 398, 399, 403, 410.
— —, experiments to ascertain the rate of the removal of the fumes of explosives, 396.
Ellington, Edward Bayrand, quoted, 199.
Elliott, Sir George, *London meeting*, 258.
—, past-president, N.E., 493.
—, quoted, 205.
Elsom improved method of lighting miners' safety-lamps when locked, 35.—Discussion, 36, 61.
Eltringham colliery, pumping arrangements at, 457.—Discussion, 464.
Elwin, T. L., prize awarded to, 472.
Embleton, T. W., *coal-dust*, 422, 430.
—, *coal-fields adjoining Barnsley*, 9.
—, — — *of Australasia*, 341, 343.
—, *detection of fire-damp*, 358.
—, *difference between the seams in the northern and southern parts of the Yorkshire coal-field*, 16.
—, *dinner at Newcastle-upon-Tyne*, 166.
—, *discussion of papers*, 16, 17, 18.
—, *distribution of electrical energy*, 160, 163.
—, *election of officers, M.*, 453.
—, inaugural address, 252.
—, *investigation of fumes of explosives*, 412, 414.
—, member of council, election, 452.
—, president, London meeting, 249.
—, quoted, 502.
—, *report of council*, 145.
—, *safety apparatus for cages*, 367.
—, *steam loop*, 149.
Engagement rules, Illawarra district, New South Wales, 317.
Engineering progress, 189.
Engine, triple-expansion, experiments upon, 347.
Engines, 121.
— at Pleasley colliery, 533.
Erratic boulders, 563.
Essaman gold mine, 82, 84.
Estuaries, temperature variation in, 564.
Evans, Dr. John, report of the corresponding societies committee of the British Association, 563.
Evans, Joan, experiments with explosives, 50.
Evaporative efficiency of boilers, 345.
Excursions during visit to Newcastle upon-Tyne, 169.
— during visit to Nottingham, 41.
Exhibition (mining) Berlin (1889), 534.
— of apparatus for prevention of overwinding, 134.
— — electric light fittings, 134.
— — model steam loop and separator, 125.
— — old mining implements, 135.
Exhibits of electric and other portable lamps, 446.
Experiments in sedimentation, 566.
— with carbonite, 85.—Description of the apparatus, 85.—Carrying out of experiments, 85.—Table of experiments, 86.—Discussion, 87, 488.
— — explosives, 49, 85, 488, 526.
— — — used in mines, 49.—Mode of carrying out the experiments, 50.—Description of the explosives tested, 51.—Results of experiments, 52.—Tables, 53, 54.—Conclusion, 56.—Discussion, 56, 488, 526.
Explosion, fire-damp, at Campagnac, 532.
— at La Machine colliery (Nièvre) 532.
—, colliery, at Polnisch-Ostrau, 534.
—, colliery, 242.
— of coal-dust, appointment of members of the S.S. to give evidence before the Royal Commission, 241.
Explosions, notes on colliery, 137.—Discussion, 143, 242.
Explosives, 2, 49, 85, 100, 488, 526.
— (flameless), 566.
— committee, investigation of fumes of explosives, 368-414, 467.
— fired into air saturated with coal-dust, 419.
—, gaseous products of the detonation of, 368, 377.
— used in mines, experiments with, 49.—Discussion, 56, 488.
— used underground, experience with, 31.—Discussion, 526.
Exports of coal from New South Wales, 282, 287.

Fairley, James, fan experiments at Craghead colliery, 175.
Fairley, W., *barometer and thermometer as applied to mining*, 502.
—, member of council, election, S.S., 116.
—, notes on colliery explosions, 137.—Discussion, 242.
—, quoted, 501.
Falmouth exhibition, 39.
Fan, Capell double inlet, at Silver Hill colliery, experiments with, 549.
—, Guibal, water-gauge of, 177.
—, medium, 217.
— ventilation, 566.
—, Waddle (1890), 173.—Discussion, 175.

Fan, Waddle, at Teversal colliery, experiments with, 542, 543.
Fans at Pleasley colliery, 534, 535.
—, duplex arrangement of centrifugal ventilating machines, 483.—Discussion, 486.
—, experiments with, 216-230.
—, experiments with, at Pleasley colliery, 535.
—, introduction of, 256.
Fantie territory, 82.
FARADAY, —., quoted, 151.
Fauna, invertebrate, investigation of, 566.
FEARN, J. W., member of council, nomination, 209; election, C. and M.C., 525.
Federated Institution of Mining Engineers, bye-laws, x.
— — — — — general meetings, iii.
— — — — — lists of officers and members, xvii.
— — — — —, titles of papers read during the year, 250.
Fenton coal, 7, 9.
— seam, 106.
FENWICK, P. J., election, C. and M.C., 209.
Fernhill colliery, explosion at, 140.
Fire-damp, detection of, 352.
— — detector, 469.
— —, determination of the flashing-point of, 586.
— — explosion at Campagnac, 582.
— —, inflammability of, 586.
FISHER, H., member of council, election, C. and M.C., 525.
FISHER, T. T., member of council, election, S.S., 116.
Fitting-up of shafts, 121.
FITTON, GEORGE, election, M., 1.
FITZWILLIAM, LORD, first fan erected at one of his collieries, 256.
Flameless explosives, 566.
Flashing-point of fire-damp, determination of, 586.
Flattened stranded ropes, 265.
Flockton coal, 7, 8, 9.
FOGGIN, WM., *experiments with explosives*, 56, 59, 60, 61.
—, locked coal wire ropes, 261.—Discussion, 266.
—, quoted, 425.
FOGGIN, WM., and M. WALTON BROWN, experiments with carbonite, 85.—Discussion, 87, 488.
FORD, ISAAC, election, M., 103.
FORMAN, J., fumes committee, 368.
FORSTER, G. B., *bending of beds near veins*, 68.
—, *experiments with carbonite*, 91.
—, member of council, election, 47, 482.
—, past-president, N.E., 493.
—, *pumping appliances at Eltringham colliery*, 464, 466.
FORSTER, T. E., prize awarded to, 472.
—, *Waddle* (1890) *fan*, 177.
FOSTER, C. LE NEVE, quoted, 74.
FOSTER, GEO., election, M., 448.
FOWLER, GEORGE, *Elsom improved method of lighting miners' safety-lamps*, 36.
—, member of council, nomination, 209; election, C. and M.C., 525.
Fowler clip-sheave, 194, 195.
FRANKLAND, Prof., electric mining safety-lamp, 92.
French commission on the inflammability of fire-damp, &c., 586.
— explosives substances commission, quoted, 50, 56, 87.
FREIRE-MARRECO, Prof., quoted, 429.
FRYAR, J. W., scrutineer, N.E., 470.
Fuel used at the gold mines on the Gold Coast, 80.
Fumes, an investigation as to whether the fumes produced from the use of roburite and tonite in coal mines are injurious to health, 368.—Report of the committee of the Durham Coal-owners' Association and of the Durham Miners' Association, 368. —Report on the chemical examination of the fumes, 369.—I. Observations made at the intake.—II. Observations made at the return. —III. Observations made after the firing of shots, 370.—Examination of the gases collected in the mines, 372. —Results of the examination of the collections made in the mines, 373.—Roburite, 373.—Tonite, 375.—Gunpowder, 376.—Solid matter suspended in the fumes, 377.—Discussion of the results, 377. —Gaseous products of the detonation of explosives, 377.—Gunpowder, 378.—Roburite, 379.—Tonite, 379.—Summary, 380.—Summarized result of the analyses, 380. —Roburite, 381.—Tonite, 382.—Gunpowder, 382.—Remarks on the results, 383.—The production of carbon monoxide, 384.—The production of nitric oxide, 384.—Composition of roburite and tonite, 385.—Report of the medical examiners on the effects produced by the explosives, 385.—Joint statements of conclusions and recommendations by Prof. Bedson, Dr. Drummond, and Dr. Hume, 388.—Appendices.—Results of the chemical examination of the fumes from the explosives, roburite, tonite, and gunpowder, 388.—Roburite, 388. —Tonite, 391.—Gunpowder, 394.—Experiments conducted at Elemore, with a view to ascertain the rate of removal of the fumes, 396.—Composition and analysis of roburite, 396.—Composition and analysis of tonite, 397.—Report of the engineer

Fumes—*Continued.*
on the experiments with explosives at Elemore, Haswell, and South Hetton collieries, 398.—Table I. Experiments with roburite at Elemore colliery, 399.—Table II. Experiments with tonite at South Hetton colliery, 401.—Table III. Experiments with roburite at Elemore colliery, 403.—Table IV. Experiments with tonite at South Hetton colliery, 405.—Table V. Experiments with blasting powder at Haswell colliery, 407.—Table VI. Experiments with blasting powder and roburite at South Hetton colliery, 409.—Table VII. Experiments with roburite at Elemore colliery, 411.—Discussion, 412, 467.
— of explosives, solid matter in, 377.
FURLONGE, W. H., quoted, 69, 74, 76.
Fuses or Germans, 100.—Discussion, 526.

GALLOWAY, W., quoted, 499, 523.
GALLWEY, ARTHUR PAYNE, nomination, N.E., 471.
GALTON, F., report of the corresponding societies committee of the British Association, 563.
GARFORTH, W. E., *discussion of papers*, 17.
—, vice-president, election, M., 452.
GARSON, Dr., ancient remains, 564.
Gaseous products of the detonation of explosives, 377.
Gases collected in the mine, examinations of, 372, 373.
Gas, natural, in Sze-Chuan, 579.
— making apparatus, experiments with, at Silver Hill, Teversal, and Pleasley collieries, 532.
— works, Basford, visit to, 41.
— —, Eastcroft, 41.
GEIKIE, Prof., geological photography, 565.
GEIPEL, —., quoted, 195.
Gelatine, blasting, 51, 54.
Gelatine-dynamite, 32.
Gelignite, 32.
—, experiments with coal-dust and, 419, 420.
Geneva, hydraulic power at, 186, 197.
Geographical society of Lisbon, 566.
Geological notes, 76.
— photography, 563, 565.
— record, 564.
— sketch of the town and district of Nottingham, 22-27.—Discussion, 522.
Geology of Australia, 299.
— — the coal-fields of Australasia, 321.
Germans, 100.—Discussion, 526.
GERRARD, J., *coal-dust*, 430.
—, *coal-field adjoining Barnsley*, 10.
—, *discussion of papers*, 17.
—, vice-president, election, M., 452.
Giffard explosive, 2.
GILCHRIST, J. R., *coal-getting by machinery*, 230.
GILLETT, L. C., election, C. and M.C., 214.
Gillott and Copley coal-cutting machines, 123, 124.
GILPIN, E., Jun., coal mining in Nova Scotia, 577.
Gladesville, boreholes, 329.
Gladstone Coal Company, 279.
Glasgow, barometer, thermometer, etc., readings at, 1890, 556.
GLENNIE, W. H., *barometer and thermometer as applied to mining*, 501.
GOEBEL, A., quoted, 441.
—, Poetsch system of sinking, 242.
Gold Coast, 69.
— — Mining and Trading Company, 82.
Gold-field in the Southern Urals, 573.
Gold-mine, Abbontuyakoon, 75.
— —, Abosso, 72.
— —, Adjah Bippoh, 75.
— —, Crookerville, 75.
— —, Effuenta, 75.
— —, Taquah, 71.
— —, Teberibi, 75.
GOLDER, Father LOUIS, brine and natural gas in Sze-Chuan, 579.
Gold River, 70.
Gonerby, 29.
GOODMAN, Prof., quoted, 343.
Governor, engine, at Eltringham colliery, 461.
Grain warehouse, Quayside, Newcastle-on-Tyne, visit to, 170.
Grand Bassam, 82.
— Hornu colliery, Belgium, Capell fan at, 220.
Grantham, 29.
Granville colliery, coal lowering arrangements, at.—Discussion, 93.
Grassmoor colliery, 24.
— — fan experiments at, 224, 229.
GRAVES, H. G., election, S.S., 116.
GRAY, W., geological photography, 565.
GRAY, Rev. J., quoted, 165.
Gray lamp, 354.
Great Gonerby, 29.
Greenhill, 29.
Green Island coal-field, 338.
— — —, analyses of coals, 326.
GREENWELL, G. C., member of council, election, 47, 482.
—, past-president, N.E., 493.
—, quoted, 182.
GREENWOOD, W. H., election, S.S., 116.
GREGORY, A. C., analyses of Australasian coals, 325.
GRESLEY, W. S, a new method of mining anthracite, 577.
Greta coal-field, 333.
— — —, analyses of coals, 324.
— colliery, 273, 280, 293.

Greymouth coal-field, 332.—Analyses of coals, 324.
Griff colliery, 199.
GRIFFITH, EDWARD, nomination, 180; election, N.E., 455.
GRIFFITH, N. R., *coal-dust*, 422, 430.
—, notes on the sinking at the Lens collieries No. 10 pit, by the Poëtsch system, 441.
GRIFFITH, W. B., quoted, 75.
GRIFFITHS, T., *experiments with explosives*, 50, 51.
GRIMMITT, WM., apparatus for the prevention of winding and overwinding accidents at collieries and blast furnaces, 243.—Discussion, 246.
GROS, JULES, quoted, 83.
GUIBAL, THEO., quoted, 487.
Guibal fan, 219, 220, 221.
— —, water-gauge, 177.
Guides, invention of, 255.
Gunpowder, 369, 376, 378, 380, 382.
—, experiments with, 489.
—, experiments with, and coal-dust, 419, 420.
—, investigation of fumes of, 394.
GUTERMUTH, Prof., quoted, 193.
GUTHRIE, J. K., pumping arrangements at Eltringham colliery, 457.—Discussion, 464.
GUTHRIE, R., appointed treasurer, N.E., 455.

Haddingtonshire coast, 68.
HAGGIE, MESSRS., manufacturers of a safety apparatus for cages, 363.
HALL, GEORGE, election, C. and M.C., 46.
HALL, H., coal-dust, 415.—Discussion, 422.
—, *experiments with carbonite*, 88.
—, *investigation of fumes of explosives*, 412.
—, quoted, 87, 498.
HALL, T. Y., quoted, 182.
HALL, W. F., member of council, election, N.E., 493.
—, quoted, 423.
HALSE, EDWARD, prizes awarded to, 471, 472.
—, some banket deposits of the Gold Coast, West Africa, 69.
Hamburg, arrival of Pennsylvania coal at, 235.
HARE, SAMUEL, nomination, 456; election, N.E., 470.
HARGREAVES, W., member of council, election, M., 452.
Harloxton, 29.
HARPER, HERBERT, election, M., 447.
HARRIES and LAWRENCE, quoted, 155.
Harrison coal-getter, 233.
HARTNELL, WILSON, quoted, 348.
Haswell colliery, experiments with gunpowder at, 369, 376.
Haswell colliery, examination of fumes of gunpowder at, 394.
— —, report on experiments with explosives at, 398, 406.
Haulage, underground, at Pleasley colliery, 537-541,
— — — Teversal colliery, 545.
Hauling engines, 121.
Hawkesbury river, 269.
— sandstones, 271, 322, 330.
— series, 269.
Haydock collieries, experiments with coal-dust at, 428.
HAY, WM., Jun., nomination, 456; election, N.E., 470.
HAYWARD, W. J., *vote of thanks to president*, 358.
HEATHCOTE, HARRY, election, C. and M.C., 511.
Hebburn colliery, explosion at, 138.
HECKELS, RICHD., quoted, 194.
HEDLEY, CHARLES, election, M., 112.
HEDLEY, JOHN HUNT, nomination, 180; election, N.E., 455.
HEDLEY, J. L., member of council, election, N.E., 493.
HEDLEY, S. H., *coal-field adjoining Barnsley*, 105, 107, 109.
— member of council, election, M., 452.
Helensburgh, 276.
HELMHACKER, R., a gold-field in the Southern Urals, 578.
HENDERSON, JOSEPH J., nomination, 180; election, N.E., 455.
HENDY, J. C. B., member of council, nomination, 209; election, C. and M.C., 525.
—, the Stanton ironworks company's collieries, 531.
HENWOOD, W. J., quoted, 71.
HENZELL, ROBERT, nomination, 171; election, N.E., 179.
Hepplewhite-Gray lamp, 356.
HERBST, Prof., quoted, 218, 219, 220.
HERSCHEL, Prof. A. S., *coal-fields of Australasia*, 341.
—, *economical use of steam in colliery engines*, 352.
—, prize awarded to, 472.
HESLINGTON, ALFRED, election, C. and M.C., 46.
Hewing rates, &c., Bulli colliery, New South Wales, 317.
HEWITT, G., vice-president, election, C. and M.C., 524
Hill Top colliery, accident, at, 139.
HIRN, —, quoted, 196.
History of mining on the Gold Coast, 82.
HODGSON, Rev. JOHN, quoted, 165.
HODGSON, JOHN, *experiments with explosives*, 60.
HODGSON, S., quoted, 255.
HOLFORD, W. D., vice-president, election, C. and M.C., 524.
Holt-Sutherland borehole, 271, 272.

Holt-Sotheby land estate, borehole, depth, 329, 330.
Holwell, 29.
Homer Hill colliery, Capel fan at, 219.
Honorary members of the Federated Institution of Mining Engineers, xvii.
Hosiery manufactory, Bull's, 41.
Houston, J. P., election, C. and M.C., 214.
Hough, John, quoted, 136.
Hough & Son, John, presentation of old mining implements to S.S., 241.
—, Vote of thanks, 241.
Hotghall, 68.
Hours of underground workmen, 4.
Howard, W. F., *combination of mining institutes*, 567.
—, *joint meeting and excursion*, 103, 104.
—, quoted, 236.
—, secretary, C. and M.C., 525.
Howe, G., member of council, election, C. and M.C., 525.
—, member of council, election, 511.
Howe, Robert, quoted, 31.
Hoyland, 7, 8.
Hucknall colliery, 25.
— Torkard collieries visited, 41.
Hughes, H. W., *apparatus for the prevention of over-winding*, 247.
—, *steam loop and separator*, 125.
Hughes, John, *barometer and thermometer as applied to mining*, 502.
—, *coal-dust commission*, 241.
—, *detection of fire-damp*, 357, 358.
—, *steam loop*, 147.
Hume, Dr. Geo. H., fumes committee, 368.—Report on fumes, 385.—Joint statement of conclusions and recommendations, 388.
Hungary (Southern), the Annina coal-field in, 582.
Hurst, George, nomination, 456; election, N.E., 470.
Hyde colliery, explosion at, 139.
Hydraulic power, 186, 197, 198.
— — Company, of London, 432.

Ibague district, 84.
Illawarra coal-field, New South Wales, 276, 335.
— — —, analyses of coals, 325.
— — —, engagement rules, 317.
— — —, quantity and value of coke manufactured in New South Wales, 285.
— — — seams, 271.
India, Cherra Poonjee coal-field, 580.
—, Lakadong coal-field, 580.
—, Lairungao coal-field, 580.
—, Maobelarkar coal-field, 580.
—, Maosandram coal-field, 580.
Indicator tests at Eltringham colliery, 458.
Inflammability of fire-damp, &c., 58d.
Invertebrate fauna, investigation of the, 566.
Investigation of fumes of explosives, 368.—Discussion, 467.
— — the invertebrate fauna, 566.
Ironstone deposits of Leicestershire, 28.—Discussion, 525.
— workings in the lias formation, 45.

Jack, R. L., quoted, 236.
Jackson, John, *cage prop*, 97.
—, *dinner at Sheffield*, 235.
—, *distribution of electrical energy*, 95.
—, *election of president*, C. and M.C., 512.
—, *Elcom improved method of lighting miners' safety-lamps*, 26, 27.
—, *explosives used in mines*, 528, 529.
—, *geological sketch of the town and district of Nottingham*, 27, 524.
—, *ironstone deposits of Leicestershire*, 29.
—, *joint meeting and excursion*, 104.
—, member of council, election, 511.
—, past-president, C. and M.C., 525.
—, *presidential address*, C. and M.C., 521, 522.
—, quoted, 236.
—, *report of the Council, C. and M.C.*, 503.
—, *S.C.P. miners' electric safety-lamp*, 49.
—, *Soar coal lowering arrangements*, 92, 94.
—, *technical education*, 99.
—, *visit to Nunnery colliery*, 215.
Jaintia Hills, the Lakadong coal-field (India) 580.
Jamberoo seams, 278.
James, David, election, S.S., 116.
Jeffs, O. W., geological photography, 563, 565.
—, quoted, 565.
Jepson, H., scrutineer, N.E., 470.
Jevons, Prof., quoted, 182.
Joicey, James John, nomination, N.E., 471.
Jordan, —., quoted, 79.

Kaitangata coal-field, 337.
— — —, analyses of coals, 325.
Kapp, Gisbert, quoted. 200.
Kawa Kawa coal-field, 334.
— — mine, analyses of coals, 325.
Kell, G. J., member of council, election, M., 452.
Kell's sections, 106.
Kellett, Matthew Henry, nomination, 172; election, N.E., 179.
Kendall, J. D., prize awarded to, 471.
Kennedy, Prof., quoted, 163.
Kew, barometer, thermometer, &c., readings at, 1890, 556.
Khasi Hills, India, the coal-fields of Lairungao, 580.
Khasia Hills, the Cherra Pongee coal-field (India), 580.

KING, W., report on the coal outcrops in Sharigh Valley, Baluchistan, 579.
KIRK & SONS, lace manufactory, 41.
KIRKUP, JOHN PHILIP, nomination, 171; election, N.E., 179.
KNOCHENHAUER, —, quoted, 69.
KNUBLEY, —, disappearance of native plants, 566.
—, geological photography, 563.
KREISCHER, Prof., quoted, 352

Labour at gold-mines on the Gold Coast, 80.
Lace manufactory, Kirk and Sons, 41.
— —, Towle's, 41.
Lairungao, the coal-field of (India), 580.
Lakadong coal-field, Jaintia Hills (India), 580.
Lake Macquarrie, analysis of coals, 325.
— — coal-field, 335.
Lakes, rivers, and estuaries, temperature variation in, 564.
La Machine colliery explosion (Nièvre), 583.
LAMB, R. O., *dinner at Newcastle-upon-Tyne*, 167.
Lamps, electric and others, 446.
— —, Pitkin portable batteries for, 444, 446.
Lanemark colliery, explosion at, 137.
LARDNER, Dr., quoted, 256.
LA TOUCHE, TOM D., the Cherra Poonjee coal-field, in the Khasia Hills (India), 580.
—, the coal-fields of Lairungao, Maosandram, and Maobelarkar, in the Khasi Hills, India, 580.
—, the Lakadong coal-fields, Jaintia Hills (India), 580.
Lauffen-Venhausen, 197.
LAURENT, —, the explosion at La Machine colliery (Nièvre), 583.
LAVERICK, JAMES, election, M., 1.
LAWRENCE, H., member of council, election, 482.
—, *transmission of power*, 203.
LAWRENCE and HARRIES, quoted, 155.
LEACH, C. C., *Waddle* (1890) *fan*. 176, 177.
LEA, HENRY, the Birmingham Central Tramways Company's electrical depôt, 127.—Cable tramway depôt, 131.
—, *steam loop and separator*, 125, 126.
Leases of gold-mines on the Gold Coast, 80.
LEBOUR, Prof. G. A., *bending of beds near veins*, 67, 68.
—, *earth tremors*, 564.
—, *electric mining safety-lamp*, 92.
—, *fan ventilation*, 566.
—, *flameless explosives*, 566.
—, *geological photography*, 565.
—, quoted, 68.
—, retirement from secretaryship, N.E., 249.
LE CHATELIER, H., quoted, 428, 429.
Leeds forge, 3.
Leen Valley, 22, 23, 24.
Leicestershire, ironstone deposits of, 28, 525.
— — working in the lias formation, 45.
Lemielle fan, 220.
Lens collieries, sinking No. 10 pit by the Poëtsch system, 441.
LEWALD, D., analyses of Australasian coals, 325.
LEWIS, G., geological sketch of the town and district of Nottingham, 22.—Discussion, 522.
—, member of council, election, 511.
—, past-president, C. and M.C., 525.
—, *S.C.P. miners' electric safety-lamp*, 40.
LEWIS, H., *distribution of electrical energy*, 96.
—, *Elsom improved method of lighting miners' safety-lamps*, 36.
—, past-president, C. and M.C., 525.
—, *S.C.P. miners' electric safety-lamp*, 39, 40.
—, *Soar coal lowering arrangements*, 93, 94.
—, *technical education*, 98, 99.
LEWIS, J. D., *experiments with explosives*, 50.
Lias formation, ironstone workings in the, 45.
LIDDELL, J. M., prizes awarded to, 471, 472.
Lidgett coal, 8, 106.
— colliery, coal-getting machinery at, 231, 233.
Life-histories of native plants, 566.
Lighting miners' safety-lamps, 35, 61.
Limestone, magnesian, 22, 531.
Linby colliery, 25, 42.
Lisbon, Geographical Society of, 566.
LISHMAN, T., fumes of explosives committee, 368.
—, member of council, election, N.E., 493.
LISHMAN, WM., fumes of explosives committee, 368.
—, vice-president, election, N.E., 493.
List of members, xvii.
Lithgow seam, section, 279.
— Valley colliery, 279.
LIVEING, E. H., prize awarded to, 471.
Liverpool district, explosions in, 138.
LIVERSIDGE, A., analyses of Australasian coals, 324, 325.
—, quoted, 74.
Lives lost by accidents from 1851-1890, 142, 143.
— — — colliery explosions, 1888, 1889, 1890, 140.
Llandridnod Wells, 3.
Llanmorlais colliery, explosion at, 140.
Local museums, 566.

Locked coil wire ropes, 261.—Flattened stranded wire ropes, 265.—Discussion, 266.
Lock (Cuvelier) for safety-lamps, 444.
Logan, W. R., quoted, 292.
London Electric Supply Corporation, Limited, 439.
London Hydraulic Power Company, 432.
Longbotham, J., *election of officers, M.*, 453.
—, *library, M.*, 452.
—, member of council, election, M., 452.
Long Clawson, 29.
Longden, J. A., *cage props*, 97.
—, *coal-getting by machinery*, 231.
—, *distribution of electrical energy*, 94, 96.
—, *economical use of steam in colliery engines*, 352.
—, *experiments with Capell and Schiele fans*, 221.
—, *explosives used in mines*, 527, 528, 529.
—, *ironstone deposits of Leicestershire*, 525.
—, *locked coil wire ropes*, 266.
—, member of council, election, 511.
—, *meetings of the C. and M.C. Institute*, 530.
—, president, nomination, 209; election, C. and M.C., 512, 524.
—, presidential address by, C. and M.C., 513.
—, quoted, 96, 222.
—, *S.C.P. miners' electric safety-lamp*, 530.
—, *technical education*, 98.
Longwall work, timbering of, 122.
Lower Llanmorlais colliery, explosion at, 140.
Low main seam, 531.—Section, 532.—Tests with, 532.
Lowrance, T. B., election, M., 448.
Lupton, Prof. A., *coal-field adjoining Barnsley*, 9.
—, *coal-getting by machinery*, 230.
—, *discussion of papers*, 16, 17.
—, *distribution of electrical energy*, 157.
—, *experiments with Capell and Schiele fans*, 217, 218, 227.
—, quoted, 18, 163, 221.
—, *steam loop*, 148.

Macarthur-Forrest process of amalgamation, 79.
— quoted, 84.
McCarthy, E., quoted, 69, 70, 76.
Macintosh, Thomas, nomination, 172; election, N.E., 179.
Mackenzie, John, quoted, 268, 272.
McLaren, John, the economical use of steam in colliery engines, 344.—Discussion, 350.
Machinery, coal-getting, 230-234.
— used at gold mines on the Gold Coast, 81.
Machines, coal-cutting, 192.
Magnesian limestone, 22, 531.
Main seam, New South Wales, 304.
Mallard, —., quoted, 428, 429.
—, report of French commission on the inflammability of fire-damp, &c., 565.
Malleable iron, introduction of, 253.
Malvern Hills coal-field, 338.
— — — —, analyses of coals, 326.
Manchester district, explosions in, 138.
Mankooma, 83.
Maobelarkar coal-field, in the Khasi Hills, India, 580.
Macsandram coal-field (India), 580.
Markets for New South Wales coal, 295.
Markham, Charles Paxton, election, C. and M.C., 46.
Marley, John, illness of, 21.—Death of, 179.—Vote of condolence, 179.
—, member of council, election, 47.
—, quoted, 28, 182.
Marlstone bed, 29.
— rock, 28, 29.
Marples, W. E., nomination, 144; election, S.S., 241.
Marreco, Prof., quoted, 429.
Marsh, F. S., Germans, 100.—Discussion, 526.
Marten, E. B., *steam loop and separator*, 125.
Marten, J. S., *Bloom improved method of lighting miners' safety-lamps*, 37.
Martin's Main colliery, 7, 107.
Marvin, C., quoted, 188.
Mason, Benjamin, nomination, 172; election, N.E., 179.
Maydew, Benjamin, election, M., 112.
May, Geo., fumes committee, 368.
—, member of council, election, 47, 482.
—, quoted, 226.
—, vice-president, election, N.E., 493.
May, Thomas Henry, election, C. and M.C., 46.
Mayor of Newcastle-upon-Tyne, *dinner at New Assembly Rooms*, 167.
Medium fan, 217.
Meiklehill colliery, explosion at, 137.
Melbourne, 29.
Melling, William, election, C. and M.C., 46.
Melly, E. T., election, C. and M.C., 214.
Melton Mowbray, 29.
Members of the Federated Institution of Mining Engineers, xviii.
Memoir of E. F. Boyd, 204.
Merivale, Prof. J. H., *centrifugal ventilating machines*, 486, 487.
—, *experiments with explosives*, 61.
—, member of council, 47, 482.
—, member of council, election, N.E., 493.
—, prize awarded to, 471.
—, *pumping appliances at Eltringham colliery*, 465.

MERIVALE, Prof. J. H., steam loop and separator, 146.—Discussion, 147.
Metallurgy, notes of papers on, 577.
Metals, action of tidal streams on.—Discussion, 110.
MEYER, JOH., colliery explosion at Polnisch-Ostrau, 584.
Middleton-in-Teasdale, 68.
MIDDLETON, ROBERT, nomination, 456; election, N.E., 470.
Midland district, explosions in, 138.
— Naturalists' society, 28.
MILLER, R., on the coal-field adjoining Barnsley, 7.—Discussion, 9, 105.
MILLS, M. H., a few notes on the iron-stone deposits of Leicestershire, 28. — Discussion, 525.
—, *dinner at Newcastle-upon-Tyne*, 168.
—, *electrical energy*, 156.
—, *explosives used in mines*, 528.
—, *geological sketch of the town and district of Nottingham*, 522.
—, member of council, election, 511.
—, *presidential address, C. and M.C.*, 521.
—, *steam loop and separator*, 147.
—, vice-president, election, C. and M.C., 524.
MILLS & SONS, brass works, visit to, 170.
Mine drainage commission, 185.
Mineral leases in New South Wales, 314.
Miners electric safety-lamp, the S.C.P., 38.—Discussion, 529.
— safety-lamps, 35, 61.
Mines, distribution of electrical energy over extended areas in.—Discussion, 94.
—, experiments with explosives used in, 49.—Discussion, 488.
—, tenure of, New South Wales, 297.
—, notes of papers on, 577.
MINGAYE, —., quoted, 277.
Mining Act of New South Wales, 314.
— and other portable lamps, 446.
— anthracite, a new method of, 577.
—, barometer and thermometer as applied to, 496.
— coal, in Nova Scotia, 577.
— exhibition, Berlin (1889), 585.
— — (old) presented to S.S., 241.
—, improvements in, 255.
— safety-lamp, 92.
MINTO, GEORGE WILLIAM, nomination, N.E., 471.
MITCHELL, JOSEPH, *action of tidal streams on metals*, 110, 111.
—, *coal-field adjoining Barnsley*, 106, 109.
—, *council's report, M.*, 449.
—, *dinner at Newcastle-upon-Tyne*, 168.
—, *dinner at Sheffield*, 234, 236.
—, *election of officers, M.*, 453.
—, *experiments with Capell and Schiele fans*, 216, 220.
MITCHELL, JOSEPH, *joint meeting and excursion*, 103, 104, 105.
—, member of council, election, 542.
—, *papers read before Federated Institutes*, 111.
—, president, election, M., 452.
—, presidential address, M., 2.
—, *valuation of library*, M., 452.
—, *visit to Nunnery colliery*, 215.
MITCHELL, T. W. H., *discussion of papers*, 16, 17.
—, secretary and treasurer, M., 452.
MITCHESON, GEORGE ARTHUR, election, N.E., 48.
MOLLER, W. A., election, C. and M.C., 214.
MOORE, JOSEPH, quoted, 198.
Moore Park borehole, 329.
MORDY, WILLIAM, nomination, 172; election, N.E., 179.
Mossfields colliery, explosion at, 139.
Mountain coal-field, 336.—Analysis of coals, 325.
Mount Keira, 276.
— Kembla Coal Company, 276.
— Osborne colliery, 8.
— Westmacott, borehole near, 329.
MURDAY, T. J., fire-damp detector, 469.
MURTON, C. J., scrutineer, N.E., 470.
—, prize awarded to, 472.
Museums, local, 566.

Narrabeen, 271, 272.
NASH, H. B., *action of tidal streams on metals*, 111.
—, *coal-field adjoining Barnsley*, 106, 107.
—, *library, M.*, 452.
—, *Parker and Weston pump*, 10.
—, member of council, election, M., 452.
Native plants, disappearance of, 566.
— —, life-histories of, 566.
Natural gas in Sze-Chuan (China), 579.
NAYLOR, HENRY, electon, M., 1.
NEALON, Dr., quoted, 82.
NEVIN, JOHN, *coal-field adjoining Barnsley*, 10.
—, *council's report, M.*, 449.
—, on the difference between the seams in the northern and southern parts of the Yorkshire coal-field, as shown in some of the deeper sinkings.—Discussion, 16.
New Caledonia, coal in, 581.
NEWCASTLE, MAYOR OF, *dinner at Newcastle-upon-Tyne*, 167.
Newcastle Chronicle printing office, visit to, 170.
— coal-field, New South Wales, 333.
— — — analyses of coals, 324.
— — — sections of strata, 303.
— Coal Mining Company, Limited, section of B pit, 304.
— collieries, New South Wales, synopsis of vend agreement, 309.

Newcastle district, explosions, 138.
— —, New South Wales, 272.
— — — — —, experts, 291.
— — — — —, tabular statement of coal-measures in, 327.
— — — — —, quantity and value of coke manufactured, 285.
— — — — —, Wallsend colliery, 275.
— pit, Nottingham, 25.
Newington borehole, 329.
New red sandstone, 22, 23.
New South Wales, notes on the coal-fields of, 268, 333, 335, 336.
— — —, analyses of coals, 325.
— — —, coal-measures in Newcastle district, 327.—Section, 326.
— — —, Mining Act, 314.
Newstead Abbey, visit to, 42.
— colliery, 25.
New Zealand coal-fields, 331, 332, 334, 337, 338.
— — — —, analyses of coals, 324, 325, 326.
Niagara Cataract Construction Company, 202.
Nièvre, the explosion at La Machine colliery, 583.
Nitric oxide, production of, 384.
Nitro-glycerine, 32.
Noble, Captain, quoted, 378, 380, 491.
North Biddick colliery, experiments with explosives at, 85.
North Gawber colliery, explosion at, 138.
— Scarle boring, 522.
— Tyne, 68.
Northern district, New South Wales, statistics of, 283-290.
Northumberland and Durham coal-field, output and duration of, 181, 182.
— Coal Mining Company, New South Wales, section, 306.
— colliery, New South Wales, 275.
Northumberland, Duke of, quoted, 165.
Notes of papers on the working of mines, &c., 577.
— on colliery explosions, 137.—Scotland, 137.—Newcastle, Durham, Yorkshire and Lincolnshire, Manchester, Liverpool and Midland districts, 138.—North and South Staffordshire and South Western districts, 139.—South Wales, 140.—Table I., 140.—Table II., 142.—Tables III. and IV., 143.—Discussion, 143.
— — the coal-fields of New South Wales, 268.—Newcastle district, 272.—Illawarra district, 276.—Statistics, 280.—Northern district, 288.—Western district, 289.—Systems of working, 292.—Markets, 295.—Tenure of mines, 297.—Appendix A, extracts from "The Physical Structure and Geology of Australia," 299.—Appendix B, sections of strata in the Newcastle coal-field, 303.—Appendix C, synopsis of vend agreement of Newcastle collieries, dated February 12, 1889, 309.—Appendix D, New South Wales Mining Act, 314.—Appendix E, copy of engagement rules, Illawarra district; rules of employment, and rates for hewing coal, yardage, &c., at the Bulli colliery, 317.—Discussion, 340.
Notes on the present position of the question of transmission of power, 191.—Steam, 191.—Compressed air, 192.—Wire rope transmission, 194.—Teledynamic transmission, 196.—Geneva, hydraulic power, 197.—Hydraulic distribution, 197.—Hydraulic transmission for mines, 198.—Electrical transmission, 200.—Conclusion, 202.—Discussion, 203.
— — — sinking of the Lens colliery, No. 10 pit, by the Poëtsch system, 441.
Nottingham, a geological sketch of the town and district of, 22.—Discussion, 522.
Nottinghamshire coal-field, 22.
Nova Scotia, coal mining in, 577.
— —, locked coil wire ropes in, 263.
Nunnery colliery, Sheffield.—Description, 227.—The Silkstone winding engine, shaft guides, and haulage, 227.—Endless-ropes; pumping, and boilers, 238.—Ventilation, coal-washing, and electric plant, 239.
— — visit to, 215.

Oakes, C. H., member of council, election, C. and M.C., 525.
O'Driscoll, Florence, quoted, 79.
Officers, election, C. and M.C., 524.
— —, M., 452.
— —, N.E., 493.
— —, S.S., 116.
— of the Federated Institution of Mining Engineers, xvi.
Oil made at Teversal colliery, 545.
Oldbury, apparatus for the prevention of overwinding at, 247.
Old Dalby, 29.
— mining implements, exhibition of, 135.
— — —, presented, S.S., 241.
Oliver, Cuthbert John, election, C. and M.C., 46.
—, *Soar coal lowering arrangements*, 93.
Orsman, W. J., *experiments with carbonite*, 491.
Output of coal in New South Wales, 281, 283, 286, 287.
— — Newcastle and Greta coal-fields, New South Wales, 334.
Overwinding, exhibition of apparatus for prevention of, 134.
—, prevention of, 243.
Owthorpe, boring at, 522.

PALMER, H., member of council, election, N.E., 493.
PANTON, F. S., fumes committee, 368.
Papers, awards for, N.E., 471.
— read during the year, titles of, 250.
PARK, MUNGO, quoted, 72.
Parker and Weston pump for colliery purposes, 11-15.
Parkgate coal, 7, 9.
PARKIN, W., election, M., 103.
PARKINSON, WILLIAM, nomination, 180; election, N.E., 455.
PARRINGTON, M. W., fumes committee, 368, 369.
—, member of council, election, N.E., 493.
PARTON, ARTHUR, election, S.S., 241.
PARTON, T., quoted, 276.
PASFIELD, THOS., *apparatus for the prevention of overwinding*, 248.
—, member of council, election, S.S., 116.
Past-presidents, C. and M.C., 525.
—, N.E., 493.
PATTERSON, W. H., fumes committee, 368, 369.
PEAK, H. C., member of council, election, S.S., 116.
PEARCE, F. H., *discussion of papers*, 18.
—, *papers read before Federated Institutes*, 18.
Pennsylvanian coal at Hamburg, 235.
Permanent Relief Fund, 4.
PERNOLET, —., quoted, 192.
Persons employed in coal-mining in New South Wales, 285, 286.
Petroleum, 187.
— oil cannel coal, output in New South Wales, 285.
— — — — — raised, value of, in New South Wales, 285.
PHILLIPS, J. ARTHUR, quoted, 69, 71.
Photography, geological, 563, 565.
Physical structure and geology of Australia, 299.
Physicians, incorporation of the Royal College of, 257.
Pick, sparks produced by, 586.
Pieler lamp, 352.
Pindar Oaks colliery, 7, 8, 9, 105, 106.
Piper seam, thickness of, 532.
PITKIN portable batteries and hand and electric lamps, 444, 446.
Plants, native, disappearance of, 566.
— —, life-histories of, 566.
Pleasley cannel, tests with, 532.
— colliery, description of, 531-541.
— fans, experiments with, 535.
Poëtsch system of sinking at Lens collieries, No. 10 pit, 242, 441.
Polnisch-Ostrau colliery, explosion at, 584.
Pont-à-Vendin, Poëtsch system of sinking at, 242.
POOLE, PERCY G., election, S.S., 116.
Port Jackson, 269.
Portable batteries, Pitkin, 444, 446.
PORTE, —., coal in New Caledonia, 581.
POTTER, A. M., member of council, election, N.E., 493.
Power, transmission of, 191.
— used at gold mines on the Gold Coast, 80.
Prehistoric remains, 567.
President, election, C. and M.C., 524.
— —, M., 452.
— —, N.E., 493.
— —, S.S., 116.
Presidential address by Joseph Mitchell, M., 2.
— — — J. A. Longden, C. and M.C., 513.
— — — John Williamson, S.S., 117.—Sinking of shafts, 118.—Fitting up of shafts, 121.—Engines, 121.—Hauling engines, 121.—Boilers, 121.—Timbering of the face of longwall work and roads, 122.—Blasting, 122.—Safety-lamps, 122.—Coal-cutting machines, 123.—The colliery manager, 124.
— — — T. W. Embleton, 252.—Agriculture, 252.—Cranks. wagon wheels, boilers, and steam engines, 253.—Electricity, railways, shipbuilding, 254.—Mining, 255.—Discussion, 258.
— — — Wm. Cochrane, N.E., 181.
PRESTWICK, JOSEPH, election, M., 103.
PRINGLE, H. A., quoted, 276.
Prizes for papers, N.E., 471.
Produce of coal in Yorkshire, 1872-1889, 5.
Production of coal in New South Wales, 281.
— — gold mines on the Gold Coast, 81.
Prosper colliery, Germany, Capell fan at, 221.
PREECE, —., quoted, 155, 156.
Princes river, 70.
Pudding stone, 69.
Pump, Parker and Weston, 11.
Pumping arrangement at Eltringham colliery, 457.—Section of strata below the Brockwell seam, 457.—Boiler and indicator tests, 458.—Quadrants, 459.—Pumps, 460.—Governor, 461.—Water wheels, 463.—Discussion, 464.
Pumps, underground, at Teversal colliery, 546.
Purifier, Carroll, 3, 239.

Quadrants at Eltringham colliery, 459.
Queensland coal-fields, 336.
— — —, analyses of coals, 325, 336.

Railway, City and South London, 434.
Railways, development of, 254.
RAMSAY, J. A., *Waddle (1890) fan*, 176, 177.
Rathluba colliery, 274.
RAYMOND, R. W., quoted, 69.

Redheugh colliery, steam loop at, 147.
Reid, A. S., geological photography, 565.
Relief fund, 4.
Report of council, 249.
— — —, C., 504.
— — —, M., 448.
— — —, N.E., 473.
— — —, S.S., 113.
— — the corresponding societies committee of the British Association for the Advancement of Science, 563.—Sections A, 564, 571.—B, 571.—C, 563, 564, 571.—D, 566, 575.—E, 566, 575.—F, 575.—G, 566, 576.—H, 564, 567, 576.—The corresponding societies for 1889-90, 568.
— — — engineer on the experiments with explosives, 398.
— — — French commission on the inflammability of fire-damp by sparks produced by steel tools, and on the employment of electric lamps.—I., sparks produced by the pick, 585.—II., electric lamps, 586.
— on the chemical examination of the fumes of roburite and tonite in mines, 369.
— — — coal outcrops in the Sharigh Valley, Baluchistan, 580.
Reumaux, M., Poëtsch system of sinking at Lens colliery, 441.
Reynolds, Prof. O., quoted, 195, 196.
Rhodes, C. E., *coal-getting by machinery*, 231.
—, *experiments with Capell and Schiele fans*, 226.
—, member of council, election, 452.
—, quoted, 233.
Richardson's paper mills, steam loop at, 147.
Richter, Frederick, nomination, N.E., 471.
Ridsdale, —., quoted, 219.
Riley, W., election, S.S., 144.
Ritson, John, nomination, 172; election, N.E., 179.
River Ancobra, 70, 77, 82, 83, 84.
— Bonsa, 70.
— Gold, 70.
— Princes, 70.
Rivers, temperature variation in, 564.
Roads in mines, timbering of, 122.
Robertson, Dr. J. R. M., quoted, 270.
Robinson, R., member of council, election, N.E., 493.
Robson, J. T., *assisting with experiments with explosives*, 50.
Robson, T. O., member of council, election, N.E., 493.
—, prize awarded to, 472.
—, quoted, 425.
Roburite, 51, 53.
Roburite and tonite, report of the committee of the Durham Coal Owners' Association and of the Durham Miners' Association as to whether the fumes of, are injurious to health, 368.
—, composition and analysis of, 373, 385, 396.
—, experiments at Elemore, 399, 403, 409, 411.
—, South Hetton, 409.
—, experiments with, 489.
— — — coal-dust and, 419, 420.
—, products of explosion of, 379, 380, 381, 388.
Rochester, William, nomination, 48; election, N.E., 63.
Rock bed, 29.
Ropes, &c., at Pleasley colliery, 533.
—, locked coil wire, 261.
—, flattened stranded, 265.
Roscoe, Sir Henry, quoted, 3.
Ross, J. A. G., *experiments with carbonite*, 87, 89, 491.
—, *steam loop*, 147.
Routledge, Joseph Longstaffe, M., election, 1.
Royal College of Physicians, incorporation of, 257.
Rudler, F. W., quoted, 84, 193.
Rules of employment at Bulli colliery, New South Wales, 317.
Rylands, Dan, election, M., 112.

Safety apparatus for cages, 362.—Discussion, 366.
Safety-lamp, Bristöl improved electric, 443.
— electric, 92.
Safety-lamps, 122.
— —, Elsom method of relighting, 35, 61,
— —, Berlin (1889), mining exhibition, 584.
— —, Cuvelier lock for, 444.
— —, remarks on, 352.
— —, S.C.P. miners' electric, 38, 446, 529.
— —, tests made on, 355.
Salmond, W., member of council, nomination, 209; election, C. and M.C., 525.
Saltwells colliery, explosion at, 139.
Samborne, John Stukley Palmer, nomination, 456; election, N.E., 470.
Sandstones, Hawkesbury, 322.
Sandwell Park colliery, explosion at, 139.
Sawyer, A. R., quoted, 69, 74.
Scarle, North, boring near, 522.
Schaffhausen Falls, 186, 196, 197.
Schiele fan, experiments with, 216-230.
Scotland, explosions in, 137.
Scott, W. Beattie, *barometer and thermometer as applied to mining*, 500, 502.
— *coal-dust commission*, 241.

Scott, W. Beattie, *colliery explosions*, 144.
—, exhibit of old mining implements, 135.—Discussion, 136.
—, *S.C.P. miners' electric safety-lamp*, 39.
—, *steam loop and separator*, 125.
Screens, &c., at Teversal collery, 541.
— at Pleasley colliery, 536, 537.
Seaton colliery, accident at, 205.
Secretary, M. Walton Brown, appointed, 103, 249.
—, retirement of Prof. Lebour, 249.
Section, Blue Mountains, 322.
— near Teralba, New South Wales, 306.
— of borehole coal seam, New South Wales, 274, 306.
— — B pit, Newcastle Coal Mining Company, Limited, New South Wales, 304.
— — main seam, New South Wales, 304.
— — New South Wales coal-measures, 326.
— — No. 1 pit, Durham colliery, New South Wales, 304.
— — strata below the Brockwell seam, 457.
— through Newcastle coal-measures, New South Wales, 330.
Sections of Bulli seam, 277.
— — coal-seams, New South Wales, 273
— — Lithgow seam, 279.
— — seams at Silver Hill, Teversal, and Pleasley collieries, 532.
— — — worked by the Gladstone Coal Company, 279.
— — strata in the Newcastle coal-field, New South Wales, 303.
Securite, 52, 53, 54.
—, experiments with, 489.
— — — coal-dust and, 419, 420.
Sedimentation, experiments in, 588.
Seely, C. H , member of council, election, C. and M.C., 525.
Separator, Bower, 3.
Seymour, Louis Irving, nomination, 63; election, N.E., 171.
Shaft guides, invention of, 255.
— sinking, Poëtsch system of, 242.
Shafts, &c., at Pleasley colliery, 533.
— — — Teversal colliery, 541.
—, fitting up of, 121.
—, sinking of, 118.
Shag Point coal-field, 337.—Analyses of coals, 325.
Shales, Wianamatta, 322.
Sharigh Valley, Baluchistan, coal outcrops in, 580.
Shaw, James E., election, M., 103.
Shaw, John, nomination, 172; election, N.E., 179.
Sheffield Park and Attercliffe Common, guides first used at, 255.
Shincliffe, 68.
Shipbuilding, improvements in, 254.
Shot-firing, the low tension electric system of, 553.—Discussion, 526.
Shotton colliery, 68.
Silkstone coal, 7, 9, 24.
Silver Hill, black shale cannel, tests with, 532.
— — colliery, Capell fan at, 222.
— — —, description of, 531, 532, 547-552.
— — —, low main, tests with, 532.
— — — Wallsend, tests with, 532.
Simpson, J. B., *bending of beds near veins*, 68.
—, *dinner at New Assembly Rooms, Newcastle-upon-Tyne*, 164.
—, *distribution of electrical energy*, 164.
—, member of council, election, 47, 482.
—, president, N.E., 493.
—, *steam loop*, 149.
—, *Waddle* (1890) *fan*, 176, 178.
Simpson, Nelson Ashbridge, nomination, 456; election, N.E., 470.
Sinking at Lens collieries, No. 10 pit, by the Poëtsch system, 441.
— shafts, 118.
Skertchly, J. A., quoted, 69, 83.
Skey, —., analyses of Australasian coals, 324, 326.
Slee, W. H., boring by, 330.
Smith, G. E., *distribution of electrical energy*, 85.
—, S.C.P. miner's electric safety- lamp, 38.—Discussion, 529.
—, works visited, 41.
Smith, J. B., *distribution of electrical energy*, 96.
—, *explosives used in mines*, 529.
—, *ironstone deposits of Leicestershire*, 525.
—, member of council, election, C. and M.C., 525.
—, on colliery depreciation, 211.
—, *report of council, C. and M.C.*, 503.
—, *Soar coal lowering arrangements*, 93.
—, *technical education*, 98.
Smithies colliery, 7, 105.
Smyth, Brough, quoted, 69.
Smyth, Sir Warington, quoted, 362, 496.
Snell, Albion T., distribution of electrical energy over extended areas in mines.—Discussion, 94, 149, 164.
— quoted, 95.
Soar patent coal lowering arrangements, 93, 94.
Soft coal seam, 25.
Sopwith, A., *apparatus for the prevention of overwinding*, 246, 247.
—, *barometer and thermometer as applied to mining*, 501.
—, *coal-dust commission*, 241.
—, *investigation of fumes of explosives*, 413, 414.
—, quoted, 152, 153, 256.

South Africa, 69.
South Bulli colliery, 276.
South Hetton colliery, chemical examination of fumes of explosives at, 390, 391, 392, 395.
— — —, experiments with explosives at, 380, 372, 373, 374, 376, 380, 381, 382, 383.
— — —, report on experiments with explosives at, 398, 399, 400, 404, 405, 408, 409.
— Staffordshire coal-field, 185.
— Wales district, explosions in, 140.
— Western district, explosions in, 139.
SOUTHALL, A. B., *action of tidal streams on metals*, 111.
—, *coal-field adjoining Barnsley*, 106, 107, 108, 109.
—, *joint meeting and excursion*, 104.
—, *Parker and Weston pump*, 10.
SOUTHERN, T. A., *coal-dust*, 427.
—, *Ellsom improved method of lighting miners safety-lamps*, 37.
—, *experiments with Capell and Schiele fans*, 222.
—, *investigation of fumes of explosives*, 412, 413.
—, *S.C.P. miners' electric safety-lamp*, 39, 40.
—, *technical education*, 97, 98.
—, *vote of thanks to Institution of Civil Engineers*, 431.
Southern district New South Wales, analyses of coals, 325.
— — — — —, statistics, 283-290.
Southern Hungary, the Annina coal-field in, 582.
Southern Urals, a gold-field in the, 578.
Sparks produced by steel tools, 586.
SPENCER, FRANCIS H., nomination, 48; election, N.E., 63.
SPENCER, W., *detection of fire-damp*, 357, 358.
—, *explosives used in mines*, 527.
—, *geological sketch of the town and district of Nottingham*, 524.
—, *ironstone deposits of Leicestershire*, 525.
—, member of council, election, 511.
— — — —, nomination, 209; election, C. and M.C., 525.
—, *presidential address*, C. and M.C., 521.
—, *S.C.P. miners' electric safety-lamp*, 40.
Staffordshire, North and South, explosions in, 139.
STANLEY heading machine, 124.
Stanton Iron Company, 29.
— Ironworks Company's collieries, 531. —Depth of pits to each seam, 532.—Detailed sections of seams now being worked, 532.—Results of tests made with different kinds of coals, 532.—Pleasley colliery, 533.—Shafts, &c., ropes, &c., cages, tubs, winding engines and boilers, 533.—Fans, 534.—Experiments with fans, 534.—Belts and screens, 536.—Engines and gear, screens, tipplers, electric and underground haulage, 537.—Electric haulage plant, 540.—Teversal colliery, 541.—Shafts, &c., 541.—Tubs, 541.—Winding engines, 541.—Belts, screens, &c., 541.—Fan, 542.—Waddle fan experiments, 543.—Boilers, 544.—Coke ovens, 544.—Oil, 545.—Underground haulage, 545.—Underground pumps, 546.—Silver Hill colliery, 547.—Winding engines, 547.—Boilers, 547.—Ventilation, 548.—Experiments with a Capell double inlet fan, 549.—Belts, &c., 550.—Low main belts, 550.—Coke ovens, 550.—Conclusion, 552.
Stanwell Park, boreholes, 329.
Statistics, coal-fields of New South Wales, 280.
Stauss system of colliery cage props.—Discussion, 97.
Steam, 191.
—, economical use of, in colliery engines, 344.
— engines, development of, 253.
— loop and separator, 146.—Discussion, 147.
— — — —, exhibition of model, 125.
—, raising and application of, 184.
STEAVENSON, A. L., *coal-dust*, 426.
—, *dinner at Newcastle-upon-Tyne*, 168.
—, *distribution of electrical energy*, 154-157.
—, *electric mining safety-lamp*, 92.
—, *experiments with carbonite*, 87.
— — — *explosives*, 56, 60, 61.
—, fumes committee, 368.
—, *investigation of fumes*, 412.
—, member of council, election, 47, 482.
—, on the present position of the question of transmission of power, 191. —Discussion, 203.
—, prize awarded to, 471.
—, *pumping appliances at Eltringham colliery*, 464, 465.
—, quoted, 161, 163.
—, *safety apparatus for cages*, 366.
—, vice-president, election N.E., 493.
—, *Waddle* (1890) *fan*, 175, 177.
STEEL, M. A., quoted, 303.
Steel tools, sparks produced by, 586.
STEPHENSON, WILLIAM, nomination, 48; election, N.E., 63.
STEVENSON, HENRY, election, C. and M.C., 46.
St. Hilda colliery, South Shields, locked coil wire ropes at, 265.
St. John ambulance association, 5.
St. John's colliery, electrical plant at, 149, 157, 159, 162.
STOBART, WILLIAM RYDER, election, N.E., 48.

STOKES, A. H., *Elsom improved method of lighting miners' safety-lamps*, 36, 37.
—, *experiments with Capell and Schiele fans*, 227.
—, *explosives used in mines*, 526, 527, 529.
—, *geological sketch of town and district of Nottingham*, 523.
—, quoted, 31, 95, 534.
STRATTON, T. H. M., *centrifugal ventilating machines*, 486, 487.
—, *members of council, election*, 482.
—, member of council, election, N.E., 493.
Sunday Creek Coal Company, 201.
Sunderland, formation of a society for the prevention of colliery accidents at, 165.
Swallow Wood coal, 7, 8, 106.
SWAN, J. W., quoted, 156.
SWINDELL, J. E., quoted, 219.
Sydney sandstones, 322.
Synopsis of vend agreement of Newcastle collieries, New South Wales, 309.
Systems of working in New South Wales, 292.
Sze-Chuan, China, brine and natural gas in, 579.

Tamso, 83.
Tamworth colliery, 219.
Taquah, 70, 76, 77, 79, 83, 84.
— gold mine, 71.
TARBUTT, W. G., *presidential address*, C. and M.C., 522.
Tasmanian coal-fields, 536.
— — —, analyses of coals, 325.
TATE, S., member of council, election, N.E., 493.
—, prize awarded to, 472.
TAYLOR, JOHN, Elsom improved method of lighting miners' safety-lamps while locked, 35-37.—Discussion, 61.
—, quoted, 182, 203.
TAYLOR, W. N., quoted, 203.
TEALE, W. E., *coal-field adjoining Barnsley*, 107.
Teberibi, 83.
— gold mine, 75, 76, 77.
Technical education, 97.
Teledynamic transmission, 196.
Temperature variation in lakes, rivers, and estuaries, 564.
TENNISON-WOODS, JULIEN E., quoted, 299.
Tenure of mines in New South Wales, 297.
Teralba Coal Company, New South Wales, 307.
TERRY, STEPHEN H., election S.S., 116.
Teversal cannel, tests with, 532.
— colliery, description of, 531, 532, 541-547.
Thénots, amalgamators, 78.
Thermometer, barometer, &c., readings, 1890, 556.
— and barometer as applied to mining, 496.
THIRKELL, E. W., *coal-field adjoining Barnsley*, 107.
—, *election of officers, M.*, 454.
THOMAS, Captain, quoted, 528.
THOMPSON, R., *representatives on council, N.E.*, 47.
Thorncliffe thin coal, 9.
Thornley, 68.
THOULET, Prof. J., experiments in sedimentation, 588.
Three-quarter seam, 532.
Tidal streams, action on metals.—Discussion, 110.
Timbering. 122.
Tipplers at Pleasley colliery, 537.
Tolima, 84.
Tonite, 52, 54.
—, composition and analysis of, 375, 385, 391, 397.
—, experiments at South Hetton with, 401, 405.
— — with, 489.
— — — coal-dust and, 419, 420.
—, investigation of fumes of, 368-414, 467.
—, products of explosion of, 379, 380, 382, 391.
Top hard seam, 23, 24, 25, 522, 523, 531.
— — —, section of, 532.
TOPLEY, W., ancient remains, 564.
—, report of the corresponding societies committee of the British Association, 563.
—, the geological record, 564.
TOWLE'S lace manufactory, 41.
Tramways Company's, Birmingham, Central Electrical depôt, 127.—Cable depôt, 131.
Transmission of power, 191.
TREGLOWN, C. H., *general meeting at Birmingham, S.S.*, 241.
—, *prevention of accidents from overwinding*, 246, 248.
TRENCH, WALTER GEORGE, election, M., 103.
Triple-expansion engine, experiments upon, 347.
Trollhätten Falls, Sweden, 186.
Tubs at Pleasley colliery, 533.
— — Teversal colliery, 541.
Tumento, 70, 83, 84.
TURNBULL, —, quoted, 293.
TURRETTINI, Col., quoted, 197.
Tursdale colliery, 376
TWIGG, ROBERT, election, S.S., 116.

Underground haulage at Pleasley colliery, 537-541.
— — — Teversal colliery, 545.
— pumps at Teversal colliery, 546.
University buildings, Nottingham, visit to, 41.

Upleatham ironstone mines, 194.
Urals (Southern), a gold-field in the, 578.

Vale colliery. Nova Scotia, locked coil wire ropes at, 263.
— of Clwydd colliery, 279.
Veins, bending of beds near, 64.—Discussion, 67.
Vend agreement, Newcastle collieries, New South Wales, 296, 309.
Ventilating fans, introduction of, 256.
— machines, duplex arrangement of centrifugal, 483.
Ventilation at Silver Hill colliery, 548.
— by fan, 566.
VERILLON, —., quoted, 83.
Vice-presidents, election, C. and M.C., 524.
— — —, M., 452.
— — —, N.E., 493.
— — —, S.S., 116.

WADDLE, HUGH, nomination, 48; election, N.E., 63.
—, *Waddle* (1890) *fan*, 175, 176, 177, 178.
Waddle (1890), fan, 173.—Experiments at Craghead colliery, 174.—Discussion, 175.
— fan, experiments at Teversal colliery, 543.
WADE, RICHARD ARMITAGE, election, C. and M.C., 511.
Waikato coal-field, New Zealand, 338.
— — —, analyses of coals, 326.
WALDEYER, C., quoted. 69.
WALES, —., quoted, 498.
Waleswood colliery, Capell fan at. 222.
WALKER, G. B., *coal-fields of Australasia*, 342.
—, member of council, election, M., 452.
—, notes on the coal-fields of New South Wales, 268.—Discussion, 340.
—, on coal-getting by machinery.—Discussion, 230.
—, on the Parker and Weston pump for colliery purposes, 11.
WALKER, R. B. N., quoted, 83.
WALKER, S. F., *the distribution of electrical energy*, 150.
—, quoted, 160.
WALKER and BONSON, quoted, 70, 71.
Walker colliery, locked coil wire ropes at, 265.
Wallarah beds, 275.
— Coal Company, 275.
— seams, 276.
WALLAU, JACOB, *centrifugal ventilating machines*, 487. 488.
—, *Waddle* (1890) *fan*, 176.
WALLIS, T. M. WINSTANLEY, quoted, 94.
—, the low tension system of shot-firing, 553.—Discussion, 526, 528.
Wallsend colliery, New South Wales, 275.
—, Silver Hill, tests with, 532.
WALTERS, HARGRAVE, an experience with explosives used underground, 31.—Discussion, 526, 527.
—, vice-president, 209; election, C. and M.C., 524.
WALTON, —, quoted, 194.
WARDLE, RICHARD, election, C. and M.C., 511.
Warratah, 275.
Wartnaby, 29.
WASHINGTON. W., scrutineer, M., 448.
Wassah country, 70, 77, 81, 82.
— Gold Mining Company, 83.
Water-gas, 3.
WATERHOUSE, Major, election, M., 448.
Waterloo seam, thickness, 532.
Water wheels at Eltringham colliery, 463.
WEEKS, R. L., *coal-dust*, 427.
—, member of council, election, N. E., 493.
—, *Waddle* (1890) *fan*, 177.
WELLS, W. E., vice-president, C. and M.C., 209.
Western district, New South Wales, statistics, 283-290.
WEYRAUCH, Prof., quoted, 193.
Whangarei coal-field. 337.
— — —, analyses of coals, 326.
Wharncliffe Silkstone colliery, 7.
WHEELER, —., *apparatus for the prevention of overwinding*, 247.
Whinmoor coal, 7, 9.
WHITAKER, W., report of the corresponding societies committee of the British Association, 563.
—, the geological record. 564.
WHITE. H., *experiments with carbonite*, 88
—, prize awarded to, 471.
White Moss colliery, experiments with coal-dust at, 428.
Whitwood colliery, explosion at, 138.
Wianamatta series, 269.
— shales, 322.
WILDE, WM., scrutineer, C. and M.C., 524.
WILKINSON, C. S., quoted, 268, 322, 329.
WILLIAMS, ERNEST, nomination, N.E., 471.
WILLIAMS, PRICE, quoted, 183.
WILLIAMSON, JOHN, barometer and thermometer as applied to mining, 496.
—, *coal-dust commission*, 241.
—, *colliery explosions*, 143.
—, president, election, S.S., 116.
—, presidential address, S.S., 117.
WILLIAMSON, R. S., member of council, election, S.S., 116.
WILLIAMSON, THOMAS, election, C. and M.C., 46.
WILLIS, JAMES, fumes committee, 368.
—, member of council, election, 47.
—, vote of condolence with family, 249.
WILSON, —., quoted, 28, 29.

WILSON, J., fumes committee, 368.
Winding appliances, Berlin (1889) mining exhibition, 585.
— engines at Pleasley colliery, 533.
— — — Silver Hill colliery. 547.
— — — Teversal colliery, 541.
WINKLER, Prof., quoted, 352.
Winnebah. 76, 77.
WINSTANLEY-WALLIS, T. M., the low tension system of shot-firing, 553.—Discussion, 526.
WINTERBOTHAM, WM., election C. and M.C., 511.
Wire rope transmission, 194.
— ropes, locked coil. 261.
Witwatersrand, 69, 74, 76.
WITZ, Prof., quoted, 202.
Wolff, benzine lamp, 352, 353.
Wollaton colliery, 25.
— —, visit to, 43.
Wombwell main, 106.
WOOD, ERNEST SEYMOUR, nomination, N.E., 471.
WOOD, HARRIE, quoted, 268.
WOOD, LINDSAY, member of council, election, 47, 482.
—, past-president, N.E., 493.
WOOD, NICHOLAS, quoted, 181, 182, 205.
WOOD, W. O., fumes committee, 368, 369.
—, member of council, election, N.E., 492.
Woodford colliery, 274.
WOODHOUSE, J. F., quoted, 498.
WOODHOUSE and RAWSON, electric miners' lamp, 446.
Woodhouse Close colliery, 194.
Woolsthorpe. 29.
Working gold mines, cost of, on the Gold Coast, 81.
— systems of, New South Wales mines, 292.
WRAY, General, quoted, 83, 84.
WRIGHT, JOSEPH, election, C. and M.C., 46.
Wyong borehole, 329.

Yard coal seam, 275, 532.
YATES, JOHN, an electrical safety apparatus for cages, 362.—Discussion, 366.
—, election, S.S., 166.
Yorkshire coal-field. 16.
— — — produce. 1872-89, 5.
— district, explosions in, 138.
—, first ventilating fan erected in, 256.
YOUNGHUSBAND, —., quoted, 247.

ZUMBULOGLON, GEORGE CHRISTOSTOM, nomination, 63; election, N.E., 171.
Zürich turbines, 197.

NORTH OF ENGLAND INSTITUTE

OF

MINING AND MECHANICAL ENGINEERS.

ANNUAL REPORT OF THE COUNCIL; ACCOUNTS; LIST OF COUNCIL,

OFFICERS, AND MEMBERS FOR THE YEAR 1891-2;

AND THE CHARTER AND BYE-LAWS;

TOGETHER WITH THE BYE-LAWS OF THE FEDERATED

INSTITUTION OF MINING ENGINEERS.

1890-91.

NEWCASTLE-UPON-TYNE AND LONDON:
ANDREW REID, SONS & CO., PRINTERS AND PUBLISHERS.
1891.

CONTENTS.

	Page
Report of Council	3
Report of Finance Committee	5
Treasurer's Accounts	6
Account of Subscriptions	8
General Statement	10
Patrons	11
Honorary Members	11
Officers	13
Members	14
Associate Members	27
Associates	28
Students	29
Subscribers under Bye-Law 19	30
Charter	31
Bye-Laws	36
Appendix to the Bye-Laws	44
Bye-Laws of the Federated Institution of Mining Engineers	53

NORTH OF ENGLAND INSTITUTE

OF

MINING AND MECHANICAL ENGINEERS.

ANNUAL REPORT OF THE COUNCIL.

The following table shows the membership during recent years:—

	August 1st.			
	1888.	1889.	1890.	1891.
Honorary Members	27	26	25	24
Members	603	569	556	535
Associate Members		28	27	29
Associates		3	25	28
Students	48	43	35	36
Subscribing Collieries	16	18	18	18
Totals	694	687	686	670

The maximum number of Members was attained on August 1st, 1877, viz:—23 Honorary Members, 792 Members, 142 Students, and 14 Subscribing Collieries, a total of 971 Members.

The effects of the Bye-Laws which came in force in 1889 are now being experienced, and there is every reason to hope that they will ultimately lead to a steady and continued increase in the membership. The class of Associates, consisting of persons occupying subordinate positions in engineering, has been successfully initiated, and must eventually tend to the efficiency of the Institute.

The Federated Institution of Mining Engineers has now completed the second year of its existence, during which there have been three general meetings—Nottingham on September 24th and 25th, 1890; Newcastle-upon-Tyne, January 21st and 22nd, 1891; and London, May 28th and 29th, 1891. These meetings have been attended by a large number of the members of the four Federated Institutes, and there has been a marked increase in the number of papers read at these meetings. In addition to receiving the papers read before this Institute, the members now receive, without extra cost, the papers read at the meetings of the Federated Institution of Mining Engineers, and of the Chesterfield and Midland Counties Institution of Engineers, the Midland Institute of Mining, Civil, and Mechanical Engineers, and the South Staffordshire and East Worcestershire Institute of Mining Engineers. With continued attention of the Federated Institutes, the Federated Institution of Mining Engineers ought eventually to include all of the institutes interested in mining, metallurgical, and mechanical engineering.

The Committee on Mechanical Ventilators has not completed its report owing to the mass of calculations required in the reduction of the experiments, but there is every reason to hope that it will be completed at an early date.

The Committee on "Flameless" Explosives hopes to commence its practical experiments shortly. Messrs. W. J. Bird and M. Walton Brown have ably translated the "Report of the French Commission on the Use of Explosives in Mines," for the use and information of the members of the Committee, and it has been issued to the members of the Institute by order of the Council, who are of opinion that this volume is a valuable addition to the publications of the Institute. Mr. M. Walton Brown was present, on the request of the Committee, at some experiments on explosives at Cymmer Collieries, and his interesting report was communicated by the Committee to the members.

The "Borings and Sinkings" are now approaching completion, and a fifth volume will be published during the ensuing year.

The Library of the Institute continues to be maintained in an efficient state, and the members in the vicinity are reminded that the books and weekly engineering papers are available daily from 10 a.m. to 5 p.m., whilst those at a distance may avail themselves of the Library by communication with the Librarian.

Material changes have taken place in the officers of the Institute through the death of Mr. F. Gosman, on September 12th, 1890, after many years of faithful attention to the interests of the Institute, and through the retirement of the Secretary, Professor Lebour, in January last. The Council trust that the appointment of their successors will tend to the efficient conduct of the business of the Institute. Mr. M. Walton Brown has been appointed Secretary and Mr. Reginald Guthrie, Treasurer.

The Institute has again been placed on the list of corresponding societies of the British Association, and the Council have appointed Professor J. H. Merivale, M.A., to act as their delegate at the ensuing meeting at Cardiff.

The Council deeply regret the death during the year of Mr. John Marley, Past-President, and of Mr. James Willis, H.M. Inspector of Mines, Vice-President—two gentlemen who have at all times contributed every assistance to the well-being of the Institute.

The papers contributed during the year are as follow:—

"Experiments with Explosives used in Mines." By Mr. M. Walton Brown.

"On the Bending of Beds near Veins." By Mr. David Burns.

"Some Banket Deposits of the Gold Coast, West Africa." By Mr. Edward Halse.

"Experiments with Carbonite." By Messrs. M. Walton Brown and William Foggin.

"The Waddle Patent (1890) Fan." By Mr. M. Walton Brown.

"On the Present Position of the Question of Transmission of Power." By Mr. A. L. Steavenson.

"On the Pumping Arrangements at Eltringham Colliery." By Mr. J. Kenneth Guthrie.

"On a Duplex Arrangement of Centrifugal Ventilating Machines." By Mr. W. Cochrane.

In concluding their fortieth annual report, while the Council congratulate the members upon the present position of the Institute, they ask them to bring its claims and advantages before others.

FINANCE REPORT.

The income for the year 1890–1 amounted to £1,790 9s. 0d.; deducting from this a sum of £200 received from the Coal Owners' Associations towards the costs to be incurred by the Explosives Committee, shows the ordinary income to be £1,590 9s. 0d., an increase of £80 14s. 10d. over the preceding year.

The total receipts for subscriptions and arrears amounted to £1,302 14s. 0d., an increase of £93 8s. 4d. The amount of subscriptions in arrear beyond one year now amount to £141 15s. 0d. The sum of £180 12s. 0d. has been struck off during the year as irrecoverable.

The total expenditure during the year has amounted to £2,232 8s. 3d., which is considerably in excess of that of the previous year, but during this year, two years' payments to the Federated Institution have been made.

August 1st, 1891. T. W. BENSON.

TREASURER IN ACCOUNT WITH THE NORTH OF ENGLAND

DR. *For the Year ending*

	£	s.	d.	£	s.	d.
July 16, 1890.						
To Balance at Bankers	510	7	10			
„ „ in hand	87	6	4			
				597	14	2
„ Dividend of 3½ per cent. on 134 Shares of £20 each in the Institute and Coal Trade Chambers Co. Ltd., for the half year ending December, 1890	93	16	0			
„ „ ending June, 1891	93	16	0			
	187	12	0			
„ Interest on Investments with the River Tyne Commissioners	73	2	6			
				260	14	6
To EXPLOSIVES COMMITTEE—						
Subscription from Durham Coal Owners' Association	150	0	0			
„ „ Northumberland „ „	50	0	0			
				200	0	0
To SUBSCRIPTIONS FOR 1890-91 AS FOLLOWS:—						
403 Ordinary Members ... ... @ £2 2s.	846	6	0			
2 Life Members	50	0	0			
23 Associate Members ... ... @ £2 2s.	48	6	0			
19 Associates ... ... @ £1 1s.	19	19	0			
18 Students ... ... @ £1 1s.	18	18	0			
1 Life Member ... ... (Balance)	17	18	0			
4 Associates ... ... @ £2 2s.	8	8	0			
4 New Members ... ... @ £2 2s.	8	8	0			
5 New Associates ... ... @ £1 1s.	5	5	0			
5 New Students ... ... @ £1 1s.	5	5	0			
1 New Associate Member ... ... @ £2 2s.	2	2	0			
	1,030	15	0			
To SUBSCRIBING COLLIERIES, VIZ.:—						
Ashington £2 2 0						
Bridgewater Trustees 6 6 0						
North Hetton 6 6 0						
Londonderry Collieries 10 10 0						
North Brancepeth 2 2 0						
Stella 2 2 0						
Victoria Garesfield 2 2 0						
Wearmouth 4 4 0						
	35	14	0			
	1,066	9	0			
To Arrears	217	7	0			
				1,283	16	0
„ Subscriptions Paid in Advance				18	18	0
„ Sale of Publications, per Secretary	26	4	6			
„ „ „ per A. Reid, Sons & Co.	0	16	0			
				27	0	6
				£2,388	3	2

INSTITUTE OF MINING AND MECHANICAL ENGINEERS.
July 31st, 1891. CR.

July 23, 1891.	£	s.	d.	£	s.	d.
By Publishing and Stationery Accounts, viz.:—						
A. Reid, Sons & Co.	168	7	2			
Lambert & Co.	82	18	4			
				251	5	6
„ Books for Library	50	15	2			
„ Printing (Annan & Swan)	5	7	6			
„ Abstracts of Foreign Papers	21	12	6			
„ Incidental Expenses	156	2	2			
„ Sundry Accounts	33	5	9			
„ Travelling Expenses	41	13	0			
„ Salaries, etc.	419	16	3			
„ Clerks' Wages	127	13	4			
„ Reporter's Salary	12	12	0			
„ Rent	97	4	8			
„ Rates and Taxes	19	7	10			
„ Insurance	9	4	11			
„ Furnishing, etc.	4	16	6			
„ Coals, Gas, and Water	22	11	7			
				1,022	3	2
„ Guibal Memorial	25	0	0			
„ Expenses of Federated Institute Meeting in Newcastle	45	3	0			
„ Explosives Committee	6	14	0			
„ Fan Committee	5	1	0			
„ Exors. of late F. Gosman	75	0	0			
By Federated Institution of Mining Engineers—						
Two Years' Calls £1,025 5 0						
Less—Payments made on behalf of the Federated Institution, as per last year's General Statement 223 3 5						
	802	1	7			
				958	19	7
By Balance at Bank	71	2	8			
„ „ in hand	84	12	3			
				155	14	11

Audited and found correct.
JOHN G. BENSON,
CHARTERED ACCOUNTANT.

Newcastle-upon-Tyne,
31st July, 1891.

£2,388 3 2

DR. THE TREASURER IN ACCOUNT

		£ s. d.	£ s. d.
To 563 Members,			
23 of whom are Life Members.			
—	Life Members (2)	50 0 0	
540	540 @ £2 2s.	1,134 0 0	
			1,184 0 0
To 29 Associate Members,			
4 of whom are Life Members.			
—	Life Member (balance)	17 18 0	
25	25 @ £2 2s.	52 10 0	
			70 8 0
To 4 Associates @ £2 2s.		8 8 0	
23 „ @ £1 1s.		24 3 0	
			32 11 0
27			
To 36 Students @ £1 1s.		.....	37 16 0
To 5 New Members @ £2 2s.		.....	10 10 0
To 2 New Associate Members @ £2 2s.		.....	4 4 0
To 5 New Associates @ £1 1s.		.....	5 5 0
To 5 New Students @ £1 1s.		.....	5 5 0
To Subscribing Collieries		.....	92 8 0
			1,442 7 0
To Arrears, as per Balance Sheet 1889-90		539 14 0	
Less—Struck out as Irrecoverable		180 12 0	
			359 2 0
To Subscriptions Paid in Advance		.....	18 18 0
			£1,820 7 0

WITH SUBSCRIPTIONS, 1890-91. CR.

		PAID. £ s. d.	UNPAID. £ s. d.
By 2	Life Members, paid	50 0 0	.....
By 1	Life Member, paid (balance)	17 18 0	.....
By 403	Members, paid ... ... @ £2 2s.	846 6 0	.....
By 111	„ unpaid ... ... @ £2 2s.	.....	233 2 0
By 2	„ transferred to Hon. Members	.....	4 4 0
By 13	„ struck off ... ... @ £2 2s.	.....	27 6 0
By 5	„ resigned ... ... @ £2 2s.	.....	10 10 0
By 6	„ dead ... ... @ £2 2s.	.....	12 12 0
540			
By 23	Associate Members, paid ... ... @ £2 2s.	48 6 0	.....
By 1	„ Member, unpaid ... ... @ £2 2s.	.....	2 2 0
By 1	„ „ resigned ... ... @ £2 2s.	.....	2 2 0
25			
By 4	Associates, paid ... ... @ £2 2s.	8 8 0	.....
By 19	„ „ ... ... @ £1 1s.	19 19 0	.....
By 4	„ unpaid ... ... @ £1 1s.	.....	4 4 0
27			
By 18	Students, paid ... ... @ £1 1s.	18 18 0	.....
By 16	„ unpaid ... ... @ £1 1s.	.....	16 16 0
By 2	„ struck off ... ... @ £1 1s.	.....	2 2 0
36			
By 4	New Members, paid ... ... @ £2 2s.	8 8 0	.....
By 1	New Member, unpaid ... ... @ £2 2s.	.....	2 2 0
5			
By 1	New Associate Member, paid ... ... @ £2 2s.	2 2 0	.....
By 1	„ „ unpaid ... @ £2 2s.	.....	2 2 0
2			
By 5	New Associates, paid ... ... @ £1 1s.	5 5 0	.....
By 5	New Students, paid ... ... @ £1 1s.	5 5 0	.....
By	Subscribing Collieries, paid	35 14 0	.....
„	„ „ unpaid	.....	56 14 0
		1,066 9 0	375 18 0
By	Arrears Paid	217 7 0	.....
„	„ Unpaid	.....	141 15 0
By	Subscriptions paid in advance	18 18 0	.....
		£1,302 14 0	517 13 0
			1,302 14 0
			£1,820 7 0

GENERAL STATEMENT, JULY 23RD, 1891.

LIABILITIES.	£	s.	d.	£	s.	d.
Subscriptions Paid in Advance	18	18	0			
Capital	11,703	19	11			
				£11,722	17	11

Audited and found correct (Share Certificates and Bonds produced).

JOHN G. BENSON,
CHARTERED ACCOUNTANT.

Newcastle-upon-Tyne,
31st July, 1891.

ASSETS.	£	s.	d.	£	s.	d.
Balance of Account at Bankers	71	2	8			
„ in Treasurer's hands	84	12	3			
				155	14	11
134 Shares of £20 each in the Institute and Coal Trade Chambers Co., Ltd.				2,680	0	0
Invested with River Tyne Commissioners ...				2,000	0	0
Arrears of Subscriptions				517	13	0
Value of 546 Bound Volumes of Transactions, @ 11s. 6d.	313	19	0			
„ 4,477 Sewn do., @ 9s.	2,014	13	0			
„ 2,405 Unbound Parts, @ 2s.	240	10	0			
„ 78 Copies Mr. T. F. Brown's Map, @ 5s.	19	10	0			
„ 376 Copies of Index, Vols. 1-25, @ 3s.	56	8	0			
„ 757 Copies of Fossil Illustrations, @ 12s. 6d.	473	2	6			
„ 850 Copies of Catalogue of Fossils, @ 5s.	212	10	0			
„ 1,500 Copies of Borings and Sinkings (Vol. I. in Sheets)	300	0	0			
„ 281 Do., Vol. I., @ 2s. 6d.	35	2	6			
„ 308 Do., Vol. II., @ 5s.	77	0	0			
„ 326 Do., Vol. III., @ 5s.	81	10	0			
„ 441 Do., Vol. IV., @ 5s.	110	5	0			
„ Sheets of Do., Vol. V., unpublished ...	65	0	0			
„ 265 Copies of Library Catalogue, @ 5s.	63	15	0			
„ 111 Copies of Report of French Commission on Explosives, Part I., @ 5s.	27	15	0			
„ 137 Do. Do. Part II., @ 5s.	34	5	0			
„ 177 Do. Do. Part III., @ 5s.	44	5	0			
				4,169	10	0
„ Office Furniture and Fittings ...	450	0	0			
„ Books and Maps in Library	1,750	0	0			
				2,200	0	0
				£11,722	17	11

Patrons.

His Grace the DUKE OF NORTHUMBERLAND.
His Grace the DUKE OF CLEVELAND.
The Most Noble the MARQUIS OF LONDONDERRY.
The Right Honourable the EARL OF LONSDALE.
The Right Honourable the EARL OF DURHAM.
The Right Honourable the EARL GREY.
The Right Honourable the EARL OF RAVENSWORTH.
The Right Honourable the EARL OF WHARNCLIFFE.
The Right Reverend the LORD BISHOP OF DURHAM.
The Very Reverend the DEAN AND CHAPTER OF DURHAM.
WENTWORTH B. BEAUMONT, Esq., M.P.

Honorary Members.

* Honorary Members during term of office only.	Elected. Mem.	Hon.
1 The Right Honourable the EARL OF RAVENSWORTH, Ravensworth Castle, Gateshead-on-Tyne		1877
2*J. B. ATKINSON, Esq., Inspector of Mines, Glasgow	1870	1888
3*W. N. ATKINSON, Esq., Inspector of Mines, Newcastle, Staffordshire	1868	1888
4*W. BEATTIE-SCOTT, Esq., Inspector of Mines, Great Barr, near Birmingham		1888
5*Prof. P. PHILLIPS BEDSON, D.Sc. (Lond.), F.C.S., Durham College of Science, Newcastle-on-Tyne		1883
6*THOMAS BELL, Esq., Inspector of Mines, Durham		
7 M. DE BOUREUILLE, Commandeur de la Légion d'Honneur, Conseiller d'état, Inspecteur Général des Mines, Paris		1853
8*Prof. G. S. BRADY, M.D., LL.D., F.R.S., F.L.S., Durham College of Science, Newcastle-on-Tyne		1875
9 Dr. BRASSERT, Berghauptmann, Bonn-am-Rhein, Prussia ...		1883
10 JOSEPH DICKINSON, Esq., F.G.S., Inspector of Mines, Manchester		1853
11*C. LE NEVE FOSTER, Esq., D.Sc., F.G.S., Inspector of Mines, Llandudno		1888
12*Prof. WILLIAM GARNETT, M.A., D.C.L., Principal of the Durham College of Science, Newcastle-on-Tyne		1884
13*HENRY HALL, Esq., Inspector of Mines, Rainhill, Prescott ...		1876
14*Prof. A. S. HERSCHEL, M.A., D.C.L., F.R.S., F.R.A.S., Observatory House, Slough, Bucks.		1872
15 The Very Rev. Dr. LAKE, Dean of Durham		1872
16*Prof. G. A. LEBOUR, M.A., F.G.S., Durham College of Science, Newcastle-on-Tyne	1873	1879
17 J. A. LONGRIDGE, Esq., Grêve d'Ayetté, Jersey		1886
18*J. S. MARTIN, Esq., Inspector of Mines, Clifton		1888

	Elected. Mem.	Hon.
19*A. E. PINCHING, Esq., Inspector of Mines, Stoke, Devonport ...		1886
20*JOSEPH T. ROBSON, Esq., Inspector of Mines, Swansea ...		1886
21*J. M. RONALDSON, Esq., Inspector of Mines, 44, Athole Gardens, Glasgow...		1886
22*A. H. STOKES, Esq., Inspector of Mines, Greenhill, Derby ...		1886
23 M. E. VUILLEMIN, Mines d'Aniche, Nord, France		1878
24*FRANK N. WARDELL, Esq., F.G.S., Inspector of Mines, Wath-on-Dearne, near Rotherham...	1864	1886

OFFICERS, 1891-92.

President.

J. B. SIMPSON, Esq., F.G.S., Hedgefield House, Blaydon-on-Tyne.

Vice-Presidents.

WM. ARMSTRONG, Sen., Esq., F.G.S., Pelaw House, Chester-le-Street.
C. BERKLEY, Esq., Marley Hill, Whickham, R.S.O., Co. Durham.
T. DOUGLAS, Esq., The Garth, Darlington.
W. LISHMAN, Esq., Bunker Hill, Fence Houses.
G. MAY, Esq., Harton Colliery Office, South Shields.
A. L. STEAVENSON, Esq., Durham.

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HENRY ARMSTRONG, Esq., Chester-le-Street.
WM. ARMSTRONG, Jun., Esq., Wingate, Co. Durham.
T. W. ASQUITH, Esq., Harperley, Lintz Green, Newcastle-upon-Tyne.
T. W. BENSON, Esq., 11, Newgate Street, Newcastle-upon-Tyne.
R. F. BOYD, Esq., Houghton-le-Spring, Fence Houses, Co. Durham.
W. F. HALL, Esq., Haswell Colliery, Haswell, *via* Sunderland.
J. L. HEDLEY, Esq., 1, Lovaine Crescent, Newcastle-upon-Tyne.
T. LISHMAN, Esq., Hetton Colliery Office, Fence Houses.
PROF. J. H. MERIVALE, M.A., 2, Victoria Villas, Newcastle-upon-Tyne.
H. PALMER, Esq., East Howle Colliery, Ferry Hill.
M. W. PARRINGTON, Esq., Wearmouth Colliery, Sunderland.
A. M. POTTER, Esq., Shire Moor Colliery, Earsdon, Newcastle-upon-Tyne.
R. ROBINSON, Esq., Howlish Hall, Bishop Auckland.
T. O. ROBSON, Esq., Redheugh Colliery, Gateshead-upon-Tyne.
T. H. M. STRATTON, Esq., Cramlington House, Northumberland.
S. TATE, Esq., Trimdon Grange Colliery, Co. Durham.
R. L. WEEKS, Esq., Willington, Co. Durham.
W. O. WOOD, Esq., South Hetton, Sunderland.

Ex-Officio.

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LINDSAY WOOD, Esq., The Hermitage, Chester-le-Street.
G. C. GREENWELL, Esq., F.G.S., Elm Tree Lodge, Duffield, Derby.
G. B. FORSTER, Esq., M.A., F.G.S., North Jesmond, Newcastle.
JOHN DAGLISH, Esq., Rothley Lake, Cambo, R.S.O., Northumberland.
SIR LOWTHIAN BELL, Bart., D.C.L., F.R.S., Rounton Grange, Northallerton.
WM. COCHRANE, Esq., Grainger Street West, Newcastle-upon-Tyne.

Past-Presidents.

T. J. BEWICK, Esq., M.I.C.E., F.G.S., Suffolk House, Laurence Pountney Hill, London, E.C. — Retiring Vice-President.

Treasurer.

REGINALD GUTHRIE, Esq., Neville Hall, Newcastle-upon-Tyne.

Secretary.

M. WALTON BROWN, Esq., Neville Hall, Newcastle-upon-Tyne.

List of Members.

JULY 31, 1891.

Members.

Marked * are Members for Life.

		Elected.
1	Ackroyd, Wm., Morley Main Collieries, Morley, near Leeds ..	Feb. 7, 1880
2	Agniel, S., Mines de Vicoigne (Nord), Nœux (P. de C.), France ...	April 23, 1887
3	Aitkin, Henry, Falkirk, N.B.	Mar. 2, 1865
4	Allan, John F., La Carolina, Provincia de St. Luis, Argentine Republic	Feb. 10, 1883
5	Allison, J. J. C., Hedley Hill Colliery, Waterhouses, Durham...	Feb. 13, 1886
6	Anderson, C. W., Belvedere, Harrogate	Aug. 21, 1852
7	Anderson, R. S., Elswick Colliery, Newcastle-on-Tyne	June 9, 1883
8	Andrews, Hugh, Swarland Hall, Felton, Northumberland ...	Oct. 5, 1872
9	Archer, T., Dunston Engine Works, Gateshead	July 2, 1872
10	Armstrong, Lord, C.B., LL.D., F.R.S., D.C.L., Cragside, Rothbury (Past-President, *Member of Council)*	May 3, 1866
11	Armstrong, Hy., Pelaw House, Chester-le-Street (*Mem. of Council*)	April 14, 1883
12	Armstrong, Wm., F.G.S., Pelaw House, Chester-le-Street (Vice-President, *Member of Council)*	Aug. 21, 1852
13	Armstrong, W., Jun., Wingate, Co. Durham *(Mem. of Council)*	April 7, 1867
14	Armstrong, W. L., Newton Lane Colliery, Victoria Coal and Coke Co., Limited, near Wakefield	Mar. 3, 1864
15	Arnold, T., Mineral Surveyor, Castle Hill, Greenfields, Llanelly	Oct. 2, 1890
16	Asquith, T. W., Harperley, Lintz Green, Newcastle-on-Tyne *(Member of Council)*	Feb. 2, 1867
17	Atkinson, A. A., Barrow Collieries, Barnsley, Yorkshire ...	Aug. 3, 1878
18	Atkinson, Fred. R., Murton Colliery, *via* Sunderland	Feb. 14, 1874
19	Aubrey, R. C., 14, St. Paul's Square, Southport	Feb. 5, 1870
20	Austine, John, Cadzow Coal Co., Glasgow	Nov. 4, 1876
21	Ayton, Henry, Cowpen Colliery, Blyth, Northumberland ...	Mar. 6, 1875
22	Bailes, E. T., Wingate, Ferryhill	June 7, 1879
23	Bailes, T., Jesmond Gardens, Newcastle	Oct. 7, 1858
24	Bailey, Samuel, 30, Waterloo Street, Birmingham	June 2, 1859
25	Bain, R. Donald, 85, Pembroke Road, Clifton, Bristol	Mar. 3, 1873
26	Bainbridge, E., Nunnery Colliery Offices, Sheffield	Dec. 3, 1863
27	Ball, Alfred F., 14, Landsdowne Terrace, Gosforth	Dec. 11, 1886
28	Banks, Thomas, 60, King Street, Manchester	Aug. 4, 1877
29	Barrett, C. R., New Seaham, Sunderland	Nov. 7, 1874
30	Bartholomew, C., Castle Hill House, Ealing, London, W. ...	Aug. 5, 1853
31	*Bartholomew, C. W., Blakesley Hall, near Towcester	Dec. 4, 1875
32	Batey, John, Newbury Collieries, Coleford, Bath...	Dec, 5, 1868

ELECTED.

33 BAUMGARTNER, W. O., Houghton-le-Spring, Fence Houses ... Sept. 6, 1879
34 BAYLDON, DANIEL HY., M.E., 3, Draper's Gardens, London, E.C. Feb. 8, 1890
35 BEANLANDS, ARTHUR, M.A., Palace Green, Durham ... ... Mar. 7, 1867
36 BELL, SIR LOWTHIAN, Bart., D.C.L., F.R.S., F.C.S., Rounton Grange, Northallerton (PAST-PRESIDENT, *Mem. of Council*) July 6, 1854
37 BELL, C. E., Park House, Durham ... ... Dec. 3, 1870
38 BELL, GEO. FRED., 4, St. Thomas' Square, Newcastle-on-Tyne ... Sept. 6, 1879
39 BENNETT, ALFRED H., Dean Lane Collieries, Bedminster, Bristol April 10, 1886
40 BENSON, J. G., Accountant, 12, Grey Street, Newcastle-on-Tyne... Nov. 7, 1874
41 BENSON, T. W., 11, Newgate Street, Newcastle (*Mem. of Council*) Aug. 2, 1866
42 BERKLEY, C., Marley Hill, Whickham, R.S.O., Co. Durham (VICE-PRESIDENT, *Member of Council*) ... ... Aug. 21, 1852
43 BERKLEY, FREDERICK, Lumley Thicks, Fence Houses ... ... Dec. 11, 1882
44 BERKLEY, R. W., Marley Hill, Whickham, R.S.O., Co. Durham ... Feb. 14, 1874
45 BEWICK, T. J., M.I.C.E., F.G.S., Suffolk House, Laurence Pountney Hill, London, E.C. (RETIRING VICE-PRESIDENT, *Member of Council*) ... ... April 5, 1860
46 BIGGE, D. SELBY, 27, Grey St. Newcastle-on-Tyne ... ... June 13, 1891
47 BIGLAND, J., Henknowle, Bishop Auckland ... ... June 4, 1857
48 BILGRAMI SYED ALI SHAMSUL ULAMA, B.A., Assoc. R.S.M., &c., Director-General of Mines, Hyderabad, Deccan, India ... April 11, 1891
49 BINNS, G. J., F.G.S., M.G.S.A., Netherseal Colliery, Burton-on-Trent ... ... Aug. 7, 1886
50 BIRAM, B., Peaseley Cross Collieries, St. Helen's, Lancashire ... 1856
51 BISHOP, JAMES, Manager, Grey Valley Coal Co., Brunnerton, Greymouth, New Zealand ... ... April 13, 1889
52 BLACK, W., Hedworth Villa, South Shields ... ... April 2, 1870
53 BLACKBURN, WM. STEVENSON, Astley House, Woodlesford, nr. Leeds Dec. 10, 1887
54 BLACKETT, W. C., Jun., Acorn Close, Sacriston, Durham ... Nov. 4, 1876
55 BLAGBURN, CHARLES, 150, Leadenhall Street, London, E.C. ... April 13, 1889
56 BLAKELEY, A. B., Soothill Wood Colliery Co., Ltd., near Batley Feb. 15, 1879
57 BOLTON, EDGAR ORMEROD, M.E., Executor of Col. Hargreaves' Colliery Offices, Burnley ... ... April 12, 1890
58 BOLTON, H. H., Newchurch Collieries, near Manchester ... ... Dec. 5, 1868
59 BOOTH, R. L., Ashington Colliery, near Morpeth 1864
60 BOUCHER, A. S., P.O. Box, 53, Krugersdorf, South African Republic ... ... Aug. 4, 1883
61 BOYD, R. F., Houghton-le-Spring, Fence Houses, Co. Durham (*Member of Council*) ... ... Nov. 6, 1869
62 BOYD, WM., North House, Longbenton, Newcastle-on-Tyne ... Feb. 2, 1867
63 BRADFORD, GEO., Witton Park, Darlington ... ... Oct. 11, 1890
64 BRAMWELL, HUGH, Clifton Coll., Great Clifton, near Workington Oct. 4, 1879
65 BRECKON, J. R., 41, Fawcett Street, Sunderland ... ... Sept. 3, 1864
66 BROJA, RICHARD, Kœniglicher Oberbergrath, 35, Friédrich Strasse, Halle, a/S. ... ... Nov. 6, 1880
67 BROUGH, THOMAS, New Seaham Colliery, Sunderland ... ... Feb. 1, 1873
68 BROWN, M. WALTON, 3, Summerhill Terrace, Newcastle-on-Tyne (SECRETARY) ... ... Oct. 7, 1871
69 BROWN, ROBERT M., Norwood Colliery, *via* Darlington ... ... April 10, 1886
70 BROWN, THOMAS, Manager, Westport Coal Co., Coalbrookdale Colliery, Westport, New Zealand ... ... April 13, 1889
71 BROWN, THOS. FORSTER, F.G.S., Guildhall Chambers, Cardiff ... 1861

		Elected.
72	BROWNE, SIR BENJAMIN C., M.I.C.E., Westacres, Benwell, Newcastle-on-Tyne...	Oct. 1, 1870
73	BRUCE, JOHN, Port Mulgrave, Hinderwell, R.S.O., Yorkshire ...	Feb. 14, 1874
74	BRYHAM, WILLIAM, Rosebridge Colliery, Wigan	Aug. 1, 1861
75	BRYHAM, W., Jun., Douglas Bank Collieries, Wigan	Aug. 3, 1865
76	BULMAN, H. F., Byer Moor, Burnopfield, near Newcastle-on-Tyne	May 2, 1874
77	BUNNING, C. Z., F.G.S., c/o The Borax Co., Limited, 2, Macri Khan, Constantinople	Dec. 6, 1873
78*	BURLS, HERBERT T., Assoc. R.S.M., F.G.S., M.E., Box 76 Barberton, Transvaal, South Africa	Feb. 9, 1889
79	BURN, JAMES, 28, Fawcett Street, Sunderland	Dec. 13, 1890
80*	BURNS, DAVID, C.E., F.G.S., Canal Bank, Carlisle	May 5, 1877
81	BURROWS, J. S., Yew Tree House, Atherton, near Manchester ...	Oct. 11, 1873
82	CABRERA, FIDEL, c/o H. Kendal and Son, 12, Great Winchester Street, London	Oct. 6, 1877
83*	CANDLER, T. E., F.G.S., Springfield, Samos Road, Anerley, London, S.E.	May 1, 1875
84	CHAMBERS, A. M., Thorncliffe Iron Works, near Sheffield ...	Mar. 6, 1869
85	CHAPMAN, ALFRED CRAWHALL, 29, St. Nicholas' Buildings, Newcastle-on-Tyne...	Oct. 13, 1866
86	CHARLTON, W. A. (of Tangyes Limited), 8, Richmond Terrace, Gateshead	Nov. 6, 1880
87	CHEESMAN, I. T., Throckley Colliery, Newcastle-on-Tyne ...	Feb. 1, 1873
88	CHEESMAN, W. T., Wire Rope Manufacturer, Hartlepool ...	Feb. 5, 1876
89	CHICKEN, LANCELOT W., Boldon Colliery, Co. Durham	June 8, 1889
90	CHILDE, HENRY S., Mining Engineer, Wakefield	Feb. 12, 1887
91	CLARK, C. F., Garswood Coal and Iron Co., Limited, near Wigan	Aug. 2, 1866
92	CLARK, R. B., Springwell Colliery, Gateshead	May 3, 1873
93	CLOUGH, JAMES, Willow Bridge, Choppington, Morpeth	April 5, 1873
94	COCHRANE, B., Aldin Grange, Durham	Dec. 6, 1866
95	COCHRANE, C., Green Royde, Pedmore, near Stourbridge ...	June 3, 1857
96	COCHRANE, W., St. John's Chambers, Grainger Street West, Newcastle (PAST-PRESIDENT, *Member of Council)*	1859
97	COCKSON, CHARLES, Ince Coal and Cannel Co., Ince, Wigan ...	April 22, 1882
98	COLE, ROBERT HEATH, Endon, Stoke-upon-Trent	Feb. 5, 1876
99	COLLIS, W. B., Swinford House, Stourbridge, Worcestershire ...	June 6, 1861
100	COLQUHOUN, T., West Stanley Colliery, Co. Durham	Dec. 14, 1889
101	COOK, J., Washington Iron Works, Washington, Co. Durham ...	May 8, 1869
102	CORBETT, V. W., Chilton Moor, Fence Houses	Sept. 3, 1870
103	CORBITT, M., Wire Rope Manufacturer, Teams, Gateshead ...	Dec. 4, 1875
104	COULSON, F., 10, Victoria Terrace, Durham...	Aug. 1, 1868
105	COULSON, W., No. 1, Pimlico, Durham	Oct. 1, 1852
106	COULTHARD, FRANCIS, Arica Villa, Fox Houses, Whitehaven ...	June 8, 1889
107	COX, JOHN H., 10, St. George's Square, Sunderland	Feb. 6, 1875
108*	COXE, E. B., Drifton, Jeddo, P.O. Luzerne Co., Penns., U.S. ...	Feb. 1, 1873
109	CRAVEN, J. HIRAM, Mechanical Engineer, Sunderland	April 12, 1890
110	CRIGHTON, JOHN, 2, Clarence Buildings, Booth Street, Manchester	Oct. 8, 1887
111	CRONE, E. W., Forest Hall, near Newcastle-on-Tyne	Mar. 5, 1870
112	CRONE, F. E., Seaton Burn Colliery, Newcastle-on-Tyne... ...	Sept. 2, 1876
113	CRONE, J. R., Tudhoe House, *via* Spennymoor	Feb. 1, 1868
114	CRONE, S. C., Forest Hall, Newcastle	1853

ELECTED.

115 CROSS, JOHN, 77, King Street, Manchester ... ... June 5, 1869
116 CROUDACE, C. J., Bettisfield Colliery Co., Ltd., Bagillt, N. Wales Nov. 2, 1872
117 CROUDACE, JOHN, West House, Haltwhistle ... ... June 7, 1873
118 CROUDACE, THOMAS, Lambton Lodge, New South Wales 1862
119 CURRY, W. THOS., Chelvey, West Town, R.S.O., Somerset ... Sept. 4, 1880

120 DACRES, THOMAS, Dearham Colliery, *via* Carlisle ... ... May 4, 1878
121 DAGLISH, JOHN, Rothley Lake, Cambo, R.S.O., Northumberland (PAST-PRESIDENT, *Member of Council*) ... ... Aug. 21, 1852
122 DAGLISH, W. S., Solicitor, Newcastle-on-Tyne ... . July 2, 1872
123 DAKERS, W. R., Croxdale Colliery, Durham ... ... Oct. 14, 1882
124 DALE, DAVID, West Lodge, Darlington ... ... Feb. 5, 1870
125 DARLING, FENWICK, South Durham Colliery, Darlington... ... Nov. 6, 1875
126 DARLINGTON, JAMES, Black Park Colliery, Ruabon, North Wales Nov. 7, 1874
127 DAVEY, HY., C.E., 3, Princes Street, Westminster, London, S.W. Oct. 11, 1873
128 DAVIES, Lt.-Col. JASPER G. S., R.E., Marton, Middlesbrough ... Aug. 3, 1889
129 DAVIES, JOHN, Hartley House, Coundon, Bishop Auckland ... April 10, 1886
130 DAVIS, KENNETH MCRAE, Dudley Coll., Northumberland ... April 13, 1889
131 DEES, J. GIBSON, Floraville, Whitehaven ... ... Oct. 13, 1883
132 DEES, R. R., Solicitor, Newcastle-on-Tyne ... ... Oct. 7, 1871
133 DENNISTON, ROBERT B., Stuart Street, Dunedin, New Zealand ... Dec. 11, 1886
134 DIXON, D. W., Lumpsey Mines, Brotton, Saltburn-by-the-Sea ... Nov. 2, 1872
135*DIXON, JAMES S., 97, Bath Street, Glasgow... ... ... Aug. 3, 1878
136 DIXON, NICH. ... ... Sept. 1, 1877
137 DIXON, R., Wire Rope Manufacturer, Teams, Gateshead... ... June 5, 1875
138 DODD, B., Bearpark Colliery, near Durham... .. .. May 3, 1866
139 DODD, M., Burncroft, Hexham ... ... Dec. 4, 1875
140*DONKIN, W., Warora Coll., Wardha Coal State Railway, C.P., India Sept. 2, 1876
141 DOUGLAS, A. S., Hucknall Torkard Collieries, Nottingham ... June 1, 1878
142 DOUGLAS, C. P., Parliament Street, Consett, Co. Durham ... Mar. 6, 1869
143 DOUGLAS, JOHN, Jun., Seghill Colliery, Dudley, Northumberland... April 22, 1882
144 DOUGLAS, M. H., Marsden Colliery, South Shields ... ... Aug. 2, 1879
145 DOUGLAS, T., The Garth, Darlington (VICE-PRESIDENT, *Member of Council*) ... . Aug. 21, 1852
146 DOWDESWELL, H., Butterknowle Colliery, *via* Darlington .. April 5, 1873
147 DOYLE, PATRICK, C.E., F.M.S., F.L.S., M.R.A.S., F.G.S., M.S.I., *Indian Engineering*, 19, Lall Bazar, Calcutta, India ... Mar. 1, 1879
148 DUNN, A. F. ... ... June 2, 1877

149 EDEN, C. H., Old Etherley, by Darlington ... ... June 14, 1890
150 EDGE, J. H., Coalport Wire Rope and Chain Works, Shifnal, Salop Sept. 7, 1878
151 ELLIOT, Sir GEORGE, Bart., M.P., D.C.L., 1, Park Street, Park Lane, London, W. (PAST-PRESIDENT, *Member of Council*) Aug. 21, 1852
152 ELLIS, W. R., F.G.S., Wigan . ... June 1, 1878
153 ELSDON, ROBERT, The Highlands, Burnt Ash Hill, Lee, Kent Nov. 4, 1876
154 ELWEN, THOMAS LEE, Littleburn Colliery, near Durham ... ... Oct. 13, 1888
155 EMBLETON, T. W., The Cedars, Methley, Leeds ... ... Sept. 6, 1855
156 EMBLETON, T. W., Jun., The Cedars, Methley, Leeds ... .. Sept. 2, 1865
157 EMINSON, J. B., Londonderry Offices, Seaham Harbour ... ... Mar. 2, 1872
158 ERSKINE, CAPT., W. C. C., Inspector of Mines, Kimberley, So. Africa Dec. 14, 1889
159 EVERARD, J. B., M.E., 6, Millstone Lane, Leicester ... ... Mar. 6, 1869

		Elected.
160	Fairley, James, Craghead and Holmside Coll., Chester-le-Street	Aug. 7, 1880
161	Farmer, A., Seaton Carew, near West Hartlepool	Mar. 2, 1872
162	Farrow, Joseph, Brotton Mines, Brotton, R.S.O.	Feb. 11, 1882
163	Favell, T. M., F.G.S., Etruria Iron Works, nr. Stoke-on-Trent	April 5, 1873
164*	Fenwick, Barnabas, 84, Osborne Road, Newcastle-on-Tyne ...	Aug. 2, 1866
165	Ferens, Frederick J., Silksworth Colliery, Sunderland	Dec. 4, 1880
166	Ferens, Robinson, Oswald Hall, near Durham	April 7, 1877
167	Ferguson, D., Persian Bank Mining Rights Corporation Ld., 6, Draper's Gardens, London, E.C.	Dec. 8, 1883
168	Fisher, Ed. R., Nant Glas, Cross Hands, near Llanelly, S. Wales...	Aug. 2, 1884
169	Fleming, C. E., Black, Hawthorn, and Co., Gateshead-on-Tyne...	April 13, 1889
170	Fletcher, H., Ladyshore Coll., Little Lever, Bolton, Lancashire	Aug. 3, 1865
171	Fletcher, John, Rock House, Ulverstone	July 2, 1872
172	Foggin, W., North Biddick Coll., Washington Station, Co. Durham	Mar. 6, 1875
173	Forrest, B. J., Villa Maria, Province of Cordoba, Argentine Republic	April 12, 1884
174	Forrest, J. C., Witley Coal Co., Limited, Halesowen, Birmingham	April 12, 1884
175	Forster, C. W., 6, East Parade, Newcastle-on-Tyne	June 10, 1882
176	Forster, G. B., M.A., F.G.S., North Jesmond, Newcastle-on-Tyne (Past-President, *Member of Council*)	Nov. 5, 1852
177	Forster, J. R., Water Company's Office, Newcastle-on-Tyne ...	July 2, 1872
178	Forster, J. T., Burnhope Colliery, near Lanchester, Co. Durham	Aug 1, 1868
179	Forster, Thomas E., North Jesmond, Newcastle-on-Tyne ...	Oct. 7, 1876
180	Foster, George, Osmondthorpe Colliery, near Leeds	Mar. 7, 1874
181	Fryar, Mark, Denby Colliery, Derby	Oct. 7, 1876
182	Galloway, T. Lindsay, M.A., Argyll Colliery, Campbeltown, N.B.	Sept. 2, 1876
183	Galloway, Wm., Mining Engineer, Cardiff	April 23, 1887
184	Geddes, George H., 142, Princes Street, Edinburgh	Oct. 1, 1881
185	Gerrard, James, 19, King Street, Wigan	Mar. 3, 1873
186	Gerrard, John, Westgate, Wakefield	Mar. 5, 1870
187	Gilchrist, J. R., Wharncliffe Silkstone Collieries, near Barnsley	Feb. 3, 1877
188	Gillett, Leonard F., 163, Osmaston Road, Derby	June 14, 1890
189	Gilroy, G., Woodlands, Parbold, near Wigan	Aug. 7, 1856
190	Gilroy, S. B., Mining Engineer, Nuneaton...	Sept. 5, 1868
191	Gjers, John, Southfield Villas, Middlesbrough	June 7, 1873
192	Goddard, F. R., Accountant, Newcastle-upon-Tyne	Nov. 7, 1874
193	Greaves, J. O., St. John's, Wakefield	Aug. 7, 1862
194	Green, J. T., Mining Engineer, Ty Celyn, Abercarne, Newport, Mon.	Dec. 3, 1870
195	Greener, Henry, South Pontop Colliery, Annfield Plain ...	Dec. 11, 1882
196	Greener, T. Y., West Lodge, Crook, Darlington...	July 2, 1872
197	Greenwell, G. C., F.G.S., Elm Tree Lodge, Duffield, Derby (Past-President, *Member of Council*)	Aug. 21, 1852
198	Greenwell, G. C., Jun., Poynton, near Stockport	Mar. 6, 1869
199	Gresley, W. S., F.G.S., Assoc. Inst. C.E., Reed House, Erie, Pa., U.S.A.	Oct. 5, 1887
200	Grey, C. G., 20, Northbrook Road, Leeson Park, Dublin ...	May 4, 1872
201	Griffith, N. R., Wrexham	1866
202	Grimshaw, E. J., 23, Hardshaw Street, St. Helens, Lancashire...	Sept. 5, 1868
203	Guthrie, James K., Eltringham Colliery, Prudhoe, R.S.O. ...	Aug. 3, 1889
204	Haddock, W. T., Jun., Ryhope Colliery, Sunderland	Oct. 7, 1876

ELECTED.

295 HAGGIE, D. H., Wearmouth Patent Rope Works, Sunderland ... Mar. 4, 1876
206 HAGGIE, PETER SINCLAIR, Gateshead-on-Tyne ... ... April 14, 1883
207*HAGUE, ERNEST, Castle Dyke, Sheffield ... ... Mar. 2, 1872
208 HAINES, J. RICHARD, Adderley Green Colliery, near Longton, Stoke-on-Trent ... ... Nov. 7, 1874
209 HALL, M., Lofthouse Station Collieries, near Wakefield ... ... Sept. 5, 1868
210 HALL, M. S., 8, Victoria Street, Bishop Auckland ... ... Feb. 14, 1874
211 HALL, TOM, Haswell Colliery, Haswell, *via* Sunderland ... ... June 8, 1889
212 HALL, WM., Murton Colliery, *via* Sunderland ... ... Dec. 4, 1875
213 HALL, WILLIAM F., Haswell Colliery, Haswell, *via* Sunderland *(Member of Council)* ... ... May 13, 1858
214 HALLAS, G. H., Wigan and Whiston Coal Co., Limited, Prescot ... Oct. 7, 1876
215 HALLIMOND, WM TASKER, Estate Manager Randt Coal Mining and Land Company, Ld., P.O. Box 506, Johannesburg, Z.A.R. Dec. 14, 1889
216 HALSE, EDWARD, 15, Clarendon Road, Notting Hill, London, W.... June 13, 1885
217 HAMILTON, E., Rig Wood, Saltburn-by-the-Sea ... ... Nov. 1, 1873
218 HANN, EDMUND, Aberaman, Aberdare ... ... Sept. 5, 1868
219 HARBOTTLE, W. H., Orrell Coal and Cannel Co., near Wigan ... Dec. 4, 1875
220 HARGREAVES, WILLIAM, Rothwell Haigh, Leeds ... ... Sept. 5, 1868
221 HARLE, RICHARD, Browney Colliery, Durham ... ... April 7, 1877
222 HARLE, WILLIAM, Pagebank Colliery, near Durham ... ... Oct. 7, 1876
223 HARRIS, W. S., Kibblesworth, Gateshead-on-Tyne ... ... Feb. 14, 1874
224 HARRISON, R., Eastwood, near Nottingham 1861
225 HARRISON, W. B., Brownhills Collieries, near Walsall ... .. April 6, 1867
226 HAY, J., Jun., Widdrington Colliery, Acklington... ... ... Sept. 4, 1869
227 HEAD, JEREMIAH, Queen's Square, Middlesbro' ... ... Aug. 3, 1889
228 HEDLEY, J. J., Derwent Cote House, Lintz Green Station ... April 6, 1872
229 HEDLEY, J. L., 1, Lovaine Crescent, Newcastle-upon-Tyne *(Member of Council)* ... ... Feb. 5, 1870
230 HEDLEY, SEPT. H., Bank Chambers, Wakefield ... ... Feb. 15, 1879
231 HEDLEY, W. H., Consett Collieries, Medomsley, Newcastle-on-Tyne 1864
232 HENDERSON, H., Pelton Colliery, Chester-le-Street ... ... Feb. 14, 1874
233 HENDERSON, Jos. J., U.S. Engineeer's Office, Kingsbridge, New York, U.S.A. ... ... June 13, 1891
234 HENSHAW, A. MAYON, Talk-o'-th'-Hill Coll., Stoke-on-Trent ... June 8, 1889
235 HEPPELL, T., Leafield House, Birtley, Chester-le-Street ... ... Aug. 6, 1863
236 HESLOP, C., Upleatham and Lingdale Mines, Upleatham, R.S.O., Yorkshire ... ... Feb. 1, 1868
237 HESLOP, GRAINGER, Deptford Hall, Sunderland ... ... Oct. 5, 1872
238 HESLOP, THOMAS, Storey Lodge Colliery, Cockfield, *via* Darlington Oct. 2, 1880
239*HEWITT, G. C., Coal Pit Heath Colliery, near Bristol ... ... June 3, 1871
240 HEWLETT, A., Haseley Manor, Warwick ... ... Mar. 7, 1861
241 HIGSON, JACOB, J. & P. Higson, 18, Booth Street, Manchester ... 1861
242 HILL, WILLIAM, Carterthorne Colliery Offices, Witton-le-Wear ... June 9, 1883
243*HILTON, J., 72, Hawkshead Street, Southport ... ... Dec. 7, 1867
244 HILTON, T. W., F.G.S., Wigan Coal and Iron Co., Limited, Wigan Aug. 3, 1865
245 HODGSON, JOHN, Edmondsley Colliery, Chester-le-Street... ... Oct. 12, 1889
246 HOLLIDAY, MARTIN F., Langley Grove, Durham ... ... May 1, 1875
247 HOLLIS, HENRY WM., North Lodge, Darlington ... ... June 8, 1889
248 HOLMES, C., Grange Hill, near Bishop Auckland ... ... April 11, 1874
249 HOMER, CHARLES J., Mining Engineer, Stoke-on-Trent ... ... Aug. 3, 1865
250 HOOD, A., 6, Bute Crescent, Cardiff ... . April 18, 1861

		Elected.
251	HOPKINS, EDWARD, Weardale Place, St. John's Chapel	Oct. 12, 1889
252	HORSLEY, W., Whitehill Point, Percy Main, Newcastle-on-Tyne	Mar. 5, 1857
253	HOSKOLD, H. D., C. and M.E., F.R.G.S., F.G.S., M. Soc. A., &c., Inspector General of Mines of the Argentine Republic, and Director of the National Department of Mines and Geology, Casilla, Correos, 900, Buenos Ayres	April 1, 1871
254	HUMBLE, JOHN, West Pelton, Chester-le-Street	Mar. 4, 1871
255	HUNTER, J.	Mar. 6, 1869
256	JACKSON, C. G., Anderton Hall, near Chorley	June 4, 1870
257	JACKSON, W. G., Hicklam House, Aberford, near Leeds	June 7, 1873
258	JACQUES, J. ROUTLEDGE, Box 21, Heidelberg, Transvaal, S.A.R.	June 8, 1889
259	JARRATT, J., Houghton Main Colliery, near Barnsley	Nov. 2, 1867
260	JEFFCOCK, T. W., 18, Bank Street, Sheffield	Sept. 4, 1869
261	JENKINS, W., M.E., Ocean Collieries, Treorky, Glamorgan ...	Dec. 6, 1862
262	JENKINS, WM., Consett Iron Works, Consett, Durham	May 2, 1874
263	JEPSON, H., 20, The Avenue, Durham	July 2, 1872
264*	JOBLING, THOS. E., Croft Villa, Blyth, Northumberland	Oct. 7, 1876
265	JOHNSON, J., Carlton Main Colliery, Barnsley	Mar. 7, 1874
266	JOHNSON, R. S., Sherburn Hall, Durham	Aug. 21, 1852
267	JOHNSON, W., Abram Colliery, Wigan	Feb. 14, 1874
268	JOHNSON, WM., Radcliffe Colliery, Acklington, Northumberland	Dec. 9, 1882
269	JOICEY, J. G., Forth Banks West Factory, Newcastle-on-Tyne ...	April 10, 1869
270	JOICEY, W. J., Sunningdale Park, Berkshire	Mar. 6, 1869
271	KAYLL, A. C., Gosforth, Newcastle-on-Tyne	Oct. 7, 1876
272	KELLETT, WILLIAM, Portland Bank, Southport	June 1, 1878
273	KENDALL, JOHN D., Roper Street, Whitehaven	Oct. 3, 1874
274	KIRKBY, J. W., Kirkland, Leven, Fife	Feb. 1, 1873
275	KIRKUP, J. P., c/o Hyderabad Deccan Co., Secunderabad, Deccan, India	April 11, 1891
276	KIRKUP, PHILIP, Cornsay Colliery Office, Esh, near Durham ...	Mar. 2, 1878
277	KIRTON, HUGH, Waldridge Colliery, Chester-le-Street	April 7, 1877
278	KNOWLES, JOHN, Westwood, Pendlebury, Manchester	Dec. 5, 1856
279*	KNOWLES, ROBERT, Ednaston Lodge, near Derby	April 10, 1886
280	LAMB, R., Bowthorn Colliery, Cleator Moor, near Whitehaven ...	Sept. 2, 1865
281	LAMB, R. O., The Lawn, Ryton-on-Tyne	Aug. 2, 1866
282	LAMB, RICHARD W., 29, Great Cumberland Place, London, W. ...	Nov. 2, 1872
283	LANCASTER, JOHN, Anfield House, Leamington	Mar. 2, 1865
284	LANCASTER, JOHN, Auchinheath, Southfield and Fence Collieries, Lesmahagow	Sept. 7, 1878
285	LANDALE, A., Comely Park Place, Dunfermline	Dec. 2, 1858
286*	LAPORTE, H., M.E., Flénu, near Mons, Belgium	May 5, 1877
287	LAVERICK, JOHN WALES, Tow Law Colliery Office, Tow Law, R.S.O., Co. Durham	Dec. 11, 1882
288	LAVERICK, ROBT., West Rainton, Fence Houses	Sept. 2, 1876
289	LAWRENCE, H., Grange Iron Works, Durham	Aug. 1, 1868
290	LAWS, W. G., Town Hall, Newcastle-on-Tyne	Oct. 2, 1880
291	LEACH, C. C., Seghill Colliery, Northumberland	Mar. 7, 1874
292	LEBOUR, G. A., M.A., F.G.S., Durham College of Science, Newcastle	Feb. 1, 1873
293	LEE, JOHN F., Castle Eden Colliery, Co. Durham	June 13, 1885

		Elected.
294	Lever, Ellis, Fan-y-Bryn, Colwyn Bay	1861
295	Lewis, Sir William Thomas, Mardy, Aberdare	1864
296	Liddell, G. H.	Sept. 4, 1869
297	Liddell, J. M., 3, Victoria Villas, Newcastle-on-Tyne	Mar. 6, 1875
298	Linsley, R., Cramlington Colliery, Northumberland	July 2, 1872
299	Linsley, S. W., Whitburn Colliery, South Shields	Sept. 4, 1869
300	Lishman, R. R., Durham Main Colliery, Durham	June 9, 1883
301	Lishman, T., Jun., Hetton Colliery, Fence Houses (*Member of Council*)	Nov. 5, 1870
302	Lishman, Wm., Holly House, Witton-le-Wear	1857
303	Lishman, Wm., Bunker Hill, Fence Houses (Vice-President, *Member of Council*)	Mar. 7, 1861
304	Lisle, J., De Beers Mine, Kimberley, So. Africa	July 2, 1872
305	Liveing, E. H., 52, Queen Anne St., Cavendish Sq., London, W.	Sept. 1, 1877
306	Livesey, C., Bradford Colliery, near Manchester	Aug. 3, 1865
307	Livesey, T., Bradford Colliery, near Manchester	Nov. 7, 1874
308	Llewellin, David Morgan, F.G.S., Glanwern Offices, Pontypool	May 14, 1881
309	Logan, William, Langley Park Colliery, Durham	Sept. 7, 1867
310	Longbotham, J., Barrow Collieries, Barnsley, Yorkshire... ...	May 2, 1868
311	Longridge, Jethro, Coxlodge Colliery, Newcastle-on-Tyne ...	Dec. 14, 1889
312	Lowdon, Thos., Colliery Manager, Hamsteels, near Durham ...	Dec. 14, 1889
313	Lupton, A., F.G.S., 6, De Grey Road, Leeds	Nov. 6, 1869
314	MacCabe, H. O., Russell Vale, Wollongong, New South Wales...	Sept. 7, 1878
315	Maddison, Thos. R., Dirtcar House, near Wakefield	Mar. 3, 1877
316	Maddison, W. H. F., The Lindens, Darlington	June, 14, 1890
317	Makepeace, H. R., Newcastle, Staffordshire	Mar. 3, 1877
318	Maling, C. T., Ellison Place, Newcastle-on-Tyne	Oct. 5, 1872
319	Mammatt, J. E., C.E., St. Andrew's Chambers, Leeds	1864
320	Markham, G. E., Howlish Offices, Bishop Auckland	Dec. 4, 1875
321	Marley, J. W., Thornfield, Darlington	Aug. 1, 1868
322	Marshall, F. C., Messrs. R. & W. Hawthorn, St. Peter's, Newcastle	Aug. 2, 1866
323	Marten, E. B., C.E., Pedmore, near Stourbridge	July 2, 1872
324	Martin, Tom Pattinson, Allhallows Colliery, Mealsgate, Carlisle	Feb. 15, 1879
325	Matthews, J., Messrs. R. and W. Hawthorn, Newcastle-on-Tyne	April 11, 1885
326	Matthews, R. F., Harehope Hall, Alnwick...	Mar. 5, 1857
327	Maughan, J. A., Manager of the Government Central Provinces' Collieries, Umaria, *via* Katni, India, C.P.	Nov. 7, 1863
328	May, G., Harton Coll. Offices, nr. South Shields (Vice-President, *Member of Council)*	Mar. 6, 1862
329	McCarthy, E. T., A.R.S.M., c/o Col. Pigott, Archer Lodge, Charles Road, St. Leonards-on-Sea, Sussex	Oct. 8, 1887
330	McCreath, J., 95, Bath Street, Glasgow	Mar. 5, 1870
331	McCulloch, David, Beech Grove, Kilmarnock, N.B.	Dec. 4, 1875
332	McLaren, B., Heddon Coal and Fire Brick Co., Wylam-on-Tyne	Dec. 10, 1883
333	McMurtrie, J., Radstock Colliery, Bath	Nov. 7, 1863
334	Merivale, Prof. J. H., M.A., 2, Victoria Villas, Newcastle-on-Tyne *(Member of Council)*	May 5, 1877
335*	Merivale, W., The Deanery, Ely	Mar. 5, 1881
336	Meysey-Thompson, A. H., Sun Foundry, Leeds	April 13, 1889
337*	Miller, N., 31, Hyde Lane, Hyde, near Manchester	Oct. 5, 1878
338	Mitchell, Chas., Jesmond, Newcastle-on-Tyne	April 11, 1874

		Elected.
339	MITCHELL, JOSEPH, Mining Offices, Eldon Street, Barnsley ...	Feb. 14, 1874
340	MITCHESON, GEORGE ARTHUR, Dresdon, Longton, Staffordshire...	Oct. 11, 1890
341	MITCHINSON, R., Jun., Pontop Colliery, Lintz Green Station, Co. Durham	Feb. 4, 1865
342	MONKHOUSE, Jos., Gilcrux, Cockermouth	June 4, 1863
343	MOOR, WM., 15, Salem Hill South, Sunderland	July 2, 1872
344	MOORE, R. W., Somerset House, Whitehaven	Nov. 5, 1870
345	MOORE, WILLIAM, Loftus Mines, Loftus-in-Cleveland, R.S.O. ...	Nov. 19, 1881
346	MOREING, C. A., Suffolk House, Laurence Pountney Hill, London, E.C.	Nov. 7, 1874
347	MORISON, JOHN, Newbattle Collieries, Dalkeith, N.B.	Dec. 4, 1880
348	MORRIS, W., Waldridge Colliery, Chester-le-Street	1858
349*	MORTON, H. J., 2, Westbourne Villas, South Cliff, Scarborough ...	Dec. 5, 1856
350	MULHOLLAND, M. L., West Cornforth, R.S.O., Co. Durham ...	Dec. 11, 1856
351	MUNDLE, ARTHUR, St. Nicholas' Chambers, Newcastle-on-Tyne...	June 5, 1875
352	MUNDLE, W., Redesdale Mines, Bellingham	Aug. 2, 1873
353	MURTON, CHAS. J., Delaval Benwell Colliery, Newcastle-on-Tyne	Mar. 6, 1880
354	MUSGRAVE, HENRY, Havercroft Main Colliery, Wakefield ...	June 12, 1886
355*	NASSE, RUDOLPH, Geheimerbergrat, Dörnsbergstrasse, 6, Berlin, W., Germany	Sept. 4, 1869
356	NEVIN, JOHN, Dunbottle House, Mirfield, Normanton	May 2, 1868
357	NICHOL, WM., De Beers Mine, Kimberley, South Africa... ...	Oct. 9, 1886
358	NICHOLSON, MARSHALL, Middleton Hall, Leeds	Nov. 7, 1863
359	NOBLE, Captain, C.B., F.R.S., F.R.A.S., F.C.S., Jesmond, Newcastle-upon-Tyne	Feb. 3, 1866
360	NORTH, F. W., F.G.S., Rowley Hall Coll, Dudley, Staffordshire	Oct. 6, 1864
361	OGDEN, JOHN M., Solicitor, Sunniside, Sunderland	Mar. 5, 1857
362	OGILVIE, A. GRAEME, 8, Grove End Road, St. John's Wood, London	Mar. 3, 1877
363	ORNSBY, R. E., Seaton Delaval Colliery, Northumberland ...	Mar. 6, 1875
364	PALMER, Sir CHAS. MARK, Bart., M.P., Quay, Newcastle-on-Tyne	Nov. 5, 1852
365	PALMER, A. S., Usworth Hall, Washington Station, Co. Durham	July 2, 1872
366	PALMER, HENRY, East Howle Colliery, near Ferryhill *(Member of Council)*	Nov. 2, 1878
367	PAMELY, C., 21, Morgan Street, Pontypridd, South Wales ...	Sept. 5, 1868
368	PANTON, F. S., Silksworth Colliery, Sunderland	Oct. 5, 1867
369	PARRINGTON, M. W., Wearmouth Colliery, Sunderland (*Member of Council*)	Dec. 1, 1864
370	PARSONS, Hon. CHARLES ALGERNON, Elvaston Hall, Ryton-on-Tyne	June 12, 1886
371	PEACE, M. W., Wigan, Lancashire	July 2, 1872
372	PEAKE, C. E.	Nov. 3, 1877
373	PEAKE, R. C., Cumberland House, Redbourn, Herts	Feb. 7, 1880
374	PEARCE, F. H., Bowling Iron Works, Bradford	Oct. 1, 1857
375	PEASE, Sir J. W., Bart., M.P., Hutton Hall, Guisbrough, Yorkshire	Mar. 5, 1857
376	PEILE, WILLIAM, Cartgate, Hensingham, Whitehaven	Oct. 1, 1863
377	PICKUP, P. W., 71, Preston New Road, Blackburn	Feb. 6, 1875
378	PLUMMER, JOHN, H.M. Inspector of Mines, Bishop Auckland ...	June 8, 1889
379	POTTER, ADDISON, C.B., Heaton Hall, Newcastle-on-Tyne ...	Mar. 6, 1869

ELECTED.

380 POTTER, A. M., Shire Moor Colliery, Earsdon, Newcastle (*Member of Council*) ... ... Feb. 3, 1872
381 POTTER, C. J., Heaton Hall, Newcastle-on-Tyne ... . Oct. 3, 1874
382 POTTS, JOS., Jun., North Cliff, Roker, Sunderland ... ... Dec. 6, 1879
383 PREST, J. J., Kimblesworth Colliery, Chester-le-Street ... ... May 1, 1875
384 PREST, T., Bedlington Colliery, R.S.O., Northumberland ... June 14, 1884
385 PRICE, J., 6, Osborne Villas, Jesmond, Newcastle-on-Tyne .. Mar. 3, 1877
386 PRICE, J. R. ... ... Aug. 7, 1869
387 PRICE, S. R., c/o Messrs. Forster Brown and Rees, Guildhall Chambers, Cardiff ... ... Nov. 3, 1877
388 PRINGLE, EDWARD, Choppington Colliery, Northumberland ... Aug. 4, 1877
389 PRINGLE, H. A., The Southern Coal Company of New South Wales, Limited, Wollongong, New South Wales ... ... Dec. 4, 1880
390*PRIOR, EDWARD G., Victoria, British Columbia ... ... Feb. 7, 1880
391 PROCTOR, C. P., Lightcliffe, near Halifax, Yorkshire ... ... Oct. 7, 1876

392 RAMSAY, J. A., Sherburn and Littletown Collieries, near Durham Mar. 6, 1869
393 RAMSAY, WM., Tursdale, Co. Durham ... ... Sept. 11, 1875
394 RATHBONE, EDGAR P., Johannesburg, P.O. Box 563, Transvaal, South Africa ... ... Mar. 7, 1874
395 REID, ANDREW, Newcastle-on-Tyne ... ... April 2, 1870
396 RHODES, C. E., Carr House, Rotherham ... ... Aug. 4, 1883
397 RICH, WILLIAM, Minas de Rio Tinto, Provincia de Huelva, Spain June 9, 1888
398 RICHARDSON, H., Backworth Colliery, Newcastle-on-Tyne ... Mar. 2, 1865
399 RICHARDSON, J. W., Iron Shipbuilder, Newcastle-on-Tyne ... Sept. 3, 1870
400 RICHARDSON, RALPH, Eppleton Colliery, Fence Houses, Co. Durham ... ... June 9, 1883
401 RIDLEY, G., 16, Dean Street, Newcastle-on-Tyne ... ... Feb. 4, 1865
402 RIDYARD, J., Bridgewater Offices, Walkden, near Bolton-le-Moors, Lancashire ... ... Nov. 7, 1874
403 RITSON, U. A., 6, Queen Street, Newcastle-on-Tyne .. ... Oct. 7, 1871
404*ROBERTSON, J. R. M., M.D., F.G.S., Linton. Mitson's Point, Sydney, N. S. W. ... ... Aug. 2, 1890
405 ROBERTSON, W., M.E., 123, St. Vincent Street, Glasgow ... Mar. 5, 1870
406 ROBINSON, G. C., Brereton and Hayes Coll., Rugeley, Staffordshire Nov. 5, 1870
407 ROBINSON, R., Howlish Hall, near Bishop Auckland (*Member of Council*) ... ... Feb. 1, 1868
408 ROBSON, J. S., Butterknowle Colliery, *via* Darlington 1853
409 ROBSON, T. O., Redheugh Colliery, Gateshead-upon-Tyne (*Member of Council*) ... ... Sept. 11, 1875
410 ROCHESTER, WILLIAM, River View, Blaydon-on-Tyne ... ... Dec. 13, 1890
411 ROGERSON, JOHN, Croxdale Hall, Durham .. .. Mar. 6, 1869
412 ROSCAMP, J., Shilbottle Coll., Lesbury, R.S.O., Northumberland Feb. 2, 1867
413 ROSS, J. A. G., Consulting Engineer Newcastle-on-Tyne ... ... July 2, 1872
414 ROSSER, W., J.P., Rhydyrhelig, Sketty, Swansea 1856
415 ROTHWELL, R. P., 27, Park Place, New York, U. S. ... ... Mar. 5, 1870
416 ROUTLEDGE, JOS., Ryhope Colliery, Sunderland .. .. Sept. 11, 1875
417 ROUTLEDGE, W. H., The Rhyd, Tredegar, Mon., Wales ... ... Oct. 7, 1876
418 RUSSELL, ROBERT, Coltness Iron Works, Newmains, N.B. ... Aug. 3, 1878
419 RUTHERFORD, W., South Derwent Coll., Annfield Plain, Lintz Green Oct. 3, 1874
420 RYDER, W. J. H., Messrs. Mills & Sons, Collingwood Street, Newcastle-on-Tyne ... ... Nov. 4, 1876

		Elected.
421*	Saise, Walter, D.Sc. (Lond.), F.G.S., M.Inst.C.E., Manager E.I.R. Collieries, Giridi, Bengal, India...	Nov. 3, 1877
422	Sawyer, A. R., Ass. R.S.M., F.G.S., late H.M. Insp. of Mines, Manager Transvalia Land Ex. and Mining Co., Ld., and La France Gold Mg. Co., Pretoria, Transvaal. Transactions to 40, Brompton Sq., London, S.W., ...	Dec. 6, 1873
423	Scarth, W. T., Raby Castle, Staindrop, Darlington	April 4, 1868
424	Scott, Andrew, Broomhill Colliery, Acklington	Dec. 7, 1867
425	Scott, C. F., Grove Cottage, Leadgate, Co. Durham	April 11, 1874
426	Scott, Walter, 46, Senhouse Street, Maryport	Sept. 6, 1879
427	Scott, Wm., Brancepeth Colliery Offices, Willington, Co. Durham	Mar. 4, 1876
428	Scoular, G., Cleator Moor, *via* Carnforth	July 2, 1872
429	Selby, Atherton, Leigh, near Manchester	Oct. 13, 1883
430	Seymour, L. Irving, De Beers Consolidated Mines, Ld., Kimberley, South Africa	Feb. 14, 1891
431	Shaw, W., Wellington Cast Steel Foundry, Middlesbrough ...	June 3, 1871
432	Shiel, John, Framwellgate Colliery, Co. Durham	May 6, 1871
433	Shipley, T., Woodland Colliery Office, Woodland, Butterknowle, R.S.O., Co. Durham	Aug. 2, 1884
434	Shone, Isaac, Great George Street Chambers, Parliament Square, London, S.W.	1866
435	Shore, Wm. Martin, Manager, Kaitangata Railway and Coal Co.'s Collieries, Otago, New Zealand	April 13, 1889
436	Shute, C. A., Portland House, Eastbourne, Darlington	April 11, 1874
437	Simpson, F. L. G., Mohpani Coal Mines, Gadawarra, C.P., India	Dec. 13, 1884
438	Simpson, F. R., Connock Chase Colliery, Walsall	Aug. 4, 1883
439	Simpson, J., Heworth Colliery, near Gateshead-on-Tyne ...	Dec. 6, 1866
440	Simpson, J. B., F.G.S., Hedgefield House, Blaydon-on-Tyne (President, *Member of Council)*	Oct. 4, 1860
441	Simpson, R., Moor House, Ryton-on-Tyne	Aug. 21, 1852
442	Slinn, T., Plashetts Colliery, Falstone, Northumberland ...	July 2, 1872
443	Smith, Eustace, Wire Rope Manufacturer & Shipbuilder, Newcastle	June 11, 1887
444*	Smith, R. Clifford, F.G.S., Ashford Hall, Bakewell	Dec. 5, 1874
445	Smith, T. E., Phœnix Foundry, Newgate St., Newcastle-on-Tyne	Dec. 5, 1874
446	Sopwith, A., Cannock Chase Collieries, near Walsall	Aug. 1, 1868
447	Sopwith, Thos., 6, Great George St., Westminster, London, S.W.	Mar. 3, 1877
448	Southern, E. O., Ashington Colliery, near Morpeth	Dec. 5, 1874
449	Southern, R., Burleigh House, The Parade, Tredegarville, Cardiff	Aug. 3, 1865
450	Southworth, Thos., Hindley Green Collieries, near Wigan ...	May 2, 1874
451	Spence, R. F., Cramlington, R.S.O., Northumberland	Nov. 2, 1878
452	Spencer, Francis H., Robinson Gold Mining Co., Witwatersrand	Dec. 13, 1890
453	Spencer, John, Westgate Road, Newcastle-on-Tyne	Sept. 4, 1869
454	Spencer, John W., Newburn, near Newcastle-on-Tyne	May 4, 1878
455	Spencer, T., Ryton, Newcastle-on-Tyne	Dec. 6, 1866
456	Stansfeld, Harold Sinclair, Flockton Manor, Wakefield ...	Oct. 13, 1888
457	Steavenson, A. L., Durham (Vice-President, *Member of Council)*	Dec. 6, 1855
458	Stephenson, G.R., 9, Victoria Cham., Westminster, London, S.W.	Oct. 4, 1860
459	Stevens, James, 9, Fenchurch Avenue, London, E.C.	Feb. 14, 1885
460	Stobart, F., Biddick Hall, Fence Houses	Aug. 2, 1873
461	Stobart, H. T., Wearmouth Colliery, Sunderland	Oct. 2, 1880
462	Stobart, W., Pepper Arden, Northallerton	July 2, 1872
463	Stobart, Wm. Ryder, Etherley Lodge, Darlington	Oct. 11, 1890

ELECTED.

464 STOKER, ARTHUR P., Birtley, near Chester-le-Street ... ... Oct. 6, 1877
465 STOREY, THOS. E., Clough Hall Iron Works, Kidsgrove, Staffordshire Feb. 5, 1872
466 STRAKER, J. H., Stagshaw House, Corbridge-on-Tyne ... ... Oct. 3, 1874
467 STRATTON, T. H. M., Cramlington House, Northumberland *(Member of Council)* ... ... Dec. 3, 1870
468 STREATFIELD, HUGH S., Ryhope Colliery, near Sunderland ... June 8, 1889
469 SWALLOW, J., Bushblades House, Lintz Green, Newcastle-on-Tyne May 2, 1874
470 SWALLOW, R. T., Wardley Hall, Newcastle-on-Tyne 1862
471 SWAN, H. F., Beaufront Castle, Hexham ... ... Sept. 2, 1871
472 SWAN, J. G., Upsall Hall, near Middlesbrough ... . Sept. 2, 1871

473 TATE, SIMON, Trimdon Grange Colliery, Co. Durham *(Member of Council* ... ... Sept. 11, 1875
474 TAYLOR, HUGH, King Street, Quay, Newcastle-on-Tyne ... ... Sept. 5, 1856
475 TAYLOR, T., Quay, Newcastle-on-Tyne ... ... July 2, 1872
476 TAYLOR-SMITH, THOMAS, Heathdale, Gosforth, Newcastle-on-Tyne Aug. 2, 1866
477 TELFORD, W. H., Hedley Hope Collieries, Tow Law, R.S.O., Co. Durham ... ... Oct. 3, 1874
478 THOMPSON, CHARLES LACY, Milton Hall, Carlisle ... ... Feb. 10, 1883
479 THOMPSON, R., Jun., 19, The Crescent, Gateshead ... ... Sept. 7, 1867
480 THOMPSON, W., Ross Buildings, Charters Towers, North Queensland, Australia ... ... Aug. 4, 1888
481 THOMSON, JOHN, Eston Mines, by Middlesbrough ... ... April 7, 1877
482 THOMSON, JOS. F., Manvers Main Colliery, Rotherham ... ... Feb. 6, 1875
483 TINN, J., C.E., Ashton Iron Rolling Mills, Bedminster, Bristol... Sept. 7, 1867
484 TODD, JOHN T., Bedford Lodge, Bishop Auckland... ... ... Nov. 4, 1876
485*TYERS, JOHN E., Nerbudda Coal and Iron Company, Limited, Mohpani Coal Mines, *via* Gadawarra, C. Provinces, India ... Dec. 10, 1887
486 TYZACK, D., F.G.S., Mining Institute, Newcastle-upon-Tyne ... Feb. 14, 1874

487 VARTY, THOMAS, Skelton Park Mines, Skelton, R.S.O., Cleveland Feb. 12, 1887
488 VITANOFF, GEO. N., Sophia, Bulgaria ... ... April 22, 1882
489 VIVIAN, JOHN, Diamond Boring Company, Whitehaven ... ... Mar. 3, 1877
490 WADDLE, HUGH, Llanmore Iron Works, Llanelly, South Wales... Dec. 13, 1890
491 WADHAM, E., C. and M.E., Millwood, Dalton-in-Furness ... Dec. 7, 1867
492 WAIN, WM. HOLT, Podmore Hall Coll., Newcastle-under-Lyne Feb. 12, 1887
493 WALKER, J. S., Pagefield Iron Works, Wigan, Lancashire ... Dec. 4, 1869
494 WALKER, SYDNEY FERRIS, 196, Severn Road, Canton, Cardiff ... Dec. 9, 1882
495 WALKER, W., Hawthorns, Saltburn-by-the-Sea ... ... Mar. 5, 1870
496 WALKER, WM., Jun., H.M. Inspector of Mines, Durham... ... Aug. 3, 1889
497 WALKER, WILLIAM EDWARD, Lowther Street, Whitehaven .. Nov. 19, 1881
498 WALLACE, HENRY, Trench Hall, Gateshead ... ... Nov. 2, 1872
499 WALLAU, JACOB, Messrs. Black, Hawthorn, and Co., Gateshead ... Dec. 10, 1887
500 WALTON, J. COULTHARD, Writhlington Coll., Radstock, *via* Bath Nov. 7, 1874
501 WARD, H., Rodbaston Hall, near Penkridge, Stafford ... ... Mar. 6, 1862
502*WARD, T. H., F.G.S., Ainlea House, Alexandra Road, Crosby, near Liverpool ... ... Aug. 7, 1882
503 WATKYN-THOMAS, W., M.E., Mineral Office, Cockermouth Castle Feb. 10, 1883
504 WATSON, THOMAS, Trimdon Colliery, Trimdon Grange ... ... Oct. 11, 1890
505 WEARS, W. G. ... ... June 9, 1888
506 WEBSTER, H. INGHAM, Morton House, Fence Houses ... ... April 14, 1883

		Elected.
507	WEEKS, J. G., Bedlington, R.S.O., Northumberland	Feb. 4, 1865
508	WEEKS, R. L., Willington, Co. Durham *(Member of Council)* ...	June 10, 1882
509	WESTMACOTT, P. G. B., Elswick Iron Works, Newcastle... ...	June 2, 1865
510	WHITE, C. E., Hebburn Colliery, near Newcastle-on-Tyne ...	Nov. 4, 1876
511	WHITE, H., Walker Colliery, Newcastle-on-Tyne	1866
512	WHITE, J. F., M.E., Wakefield	July 2, 1872
513	WHITE, J. W. H., Woodlesford, near Leeds	Sept. 2, 1876
514	WHITEHEAD, JAMES, Brindle Lodge, near Preston, Lancashire ...	Dec. 4, 1875
515	WHITELAW, JOHN, 118, George Street, Edinburgh...	Feb. 5, 1870
516	WHITTEM, THOS. S., Wyken Colliery, near Coventry	Dec. 5, 1874
517	WIDDAS, C., North Bitchburn Colliery, Howden, Darlington ...	Dec. 5, 1868
518	WIGHT, EDWD. S., Mount Keiron Colliery, Wollongong, N.S.W....	Dec. 12, 1885
519	WIGHT, W. H., Cowpen Colliery, Blyth	Feb. 3, 1877
520	WILSON, J. B., Wingfield Iron Works and Colliery, Alfreton ...	Nov. 5, 1852
521	WILSON, J. D., Ouston House, Chester-le-Street	Sept. 11, 1875
522	WILSON, JOHN ROBINSON, c/o T. A. Walker, Esq., Contractor, Manchester Ship Canal, Manchester	June 9, 1883
523	WILSON, ROBERT, Flimby Colliery, Maryport	Aug. 1, 1874
524	WILSON, W. B., Thornley Coll., by Trimdon Grange, Co. Durham	Feb. 6, 1869
525	WINSTANLEY, ROBT., M.E., 28, Deansgate, Manchester	Sept. 7, 1878
526	WINTER, T. B., Grey Street, Newcastle-on-Tyne	Oct. 7, 1871
527	WOOD, C. L., Freeland, Forgandenny, Perthshire	1853
528	WOOD, LINDSAY, The Hermitage, Chester-le-Street (PAST-PRESIDENT, *Member of Council)*	Oct. 1, 1857
529	WOOD, THOMAS, Rainton House, Fence Houses	Sept. 3, 1870
530	WOOD, W. H., Coxhoe Hall, Coxhoe, County Durham	1856
531	WOOD, W. O., South Hetton, Sunderland *(Member of Council)* ...	Nov. 7, 1863
532	WOOLCOCK, HENRY, St. Bees, Cumberland	Mar. 3, 1873
533	WORMALD, C. F., Mayfield Villa, Saltwell, Gateshead-on-Tyne ...	Dec. 8, 1885
534	WRIGHTSON, T., Stockton-on-Tees	Sept. 13, 1873
535	YOUNG, JOHN A., 7, Tyne Vale Terrace, Gateshead	Dec. 10, 1887

Associate Members.

Marked * are Life Associate Members.

		Elected.
1	Armstrong, J. H. St. Nicholas' Chambers, Newcastle-on-Tyne ...	Aug. 1, 1885
2	Armstrong, T. J., Hawthorn Terrace, Newcastle-on-Tyne ...	Feb. 10, 1883
3	Audus, T., Mineral Traffic Manager, North Eastern Railway, Newcastle-on-Tyne...	Aug. 7, 1880
4*	Bell, Thos. Hugh, Middlesbrough-on-Tees...	Dec. 11, 1882
5	Brough, Bennett H., A.R.S.M., F.G.S., 5, Robert Street, Adelphi, London, W.C.	Dec. 10, 1887
6	Burdon, A. E., Hartford House, Cramlington, Northumberland	Feb. 10, 1883
7*	Carr, William Cochran, Benwell Colliery, Newcastle-on-Tyne...	Oct. 11, 1890
8	Cochrane, Ralph D., Hetton Colliery Offices, Fenee Houses ...	June 1, 1878
9	Cockburn, W. C., 1, St. Nicholas' Buildings, Newcastle-on-Tyne	Oct. 8, 1887
10	Cooper, R. W., Solicitor, Newcastle-on-Tyne	Sept. 4, 1880
11	Edwards, F. H., Forth House, Bewick Street, Newcastle-on-Tyne	June 11, 1887
12	Fletcher, William, Brigham Hill, *via* Carlisle	Oct. 13, 1883
13	Guthrie, Reginald, Neville Hall, Newcastle (Treasurer) ...	Aug. 4, 1888
14	Hedley, E., Rainham Lodge, The Avenue, Beckenham, Kent ...	Dec. 2, 1871
15	Hedley, J. Hunt, John St., Sunderland	June 13, 1891
16	Hedley, T. F., Jun., Valuer, Sunderland	April 23, 1887
17	Henderson, C. W. C., The Riding, Hexham	Dec. 11, 1882
18	Henzell, Robt., Oil Manufacturer, Close, Newcastle-on-Tyne ...	April 11, 1891
19	Hooper, Edward, c/o J. H. Hooper, College Precincts, Worcester	June 4, 1881
20	Hopper, J. I., Wire Rope Manufacturer, Tyne Dock, South Shields	Dec. 3, 1888
21	Irvine, Joseph R., Hendon Ropery, Sunderland	Dec. 10, 1887
22*	Pease, Arthur, Darlington	Dec. 11, 1882
23*	Proctor, John H., Ironmonger, 29, Side, Newcastle-on-Tyne	June 8, 1889
24	Redmayne, R. Norman, Chemical Manufacturer, &c., 26, Grey Street, Newcastle-on-Tyne	Oct. 12, 1889
25	Ridley, Sir Matthew W., Bart., M.P., Blagdon, Northumberland	Feb. 10, 1883
26	Scurfield, George J., Hurworth-upon-Tees, Darlington ...	Dec. 11, 1882
27	Shaw, Saville, Durham College of Science, Newcastle-on-Tyne	April 13, 1889
28	Topley, William, F.R.S., F.G.S., of H.M. Geological Survey, 28, Jermyn Street, London, S.W.	Oct. 12, 1889
29	Wilson, Arthur P., Mansion House Chambers, Queen Victoria Street, London, E.C.	Aug. 3, 1889

Associates.

		Elected.
1	Barrass, M., Tudhoe Colliery, Spennymoor	Dec. 10, 1883
2	Bates, Sidney, The Grange, Prudhoe-on-Tyne	Feb. 8, 1890
3	Bell, John, Wardley Colliery, Newcastle-on-Tyne	Feb. 8, 1890
4	Chandley, Charles, Aberdare, South Wales	Nov. 6, 1880
5	Cheesman, Ed. Taylor, Blaydon Main Coll., Blaydon-on-Tyne	Aug. 2, 1890
6	Clark, Thomas, Dipton Colliery, Lintz Green Station	Oct. 11, 1890
7	Draper, William, New Seaham Colliery, Sunderland	Dec. 14, 1889
8	Forster, John William, 24, Silksworth Terrace, New Silksworth, Sunderland	Dec. 14, 1889
9	Fryar, John William, Seghill Coll., Seghill, Northumberland	June 14, 1890
10	Griffiths, Ed., High Street, Coedpoeth, Wrexham	June 13, 1891
11	Guy, John George, M.E., 8, South Terrace, Jobs Hill, Crook, R.S.O., Co. Durham	Aug. 3, 1889
12	Hall, John Charles, Pegswood Colliery, near Morpeth ...	Dec. 14, 1889
13	Hepburn, Thomas, Langley Park, Durham...	Feb. 8, 1890
14	Mackintosh, Thos. L., Waterloo, Blyth	April 11, 1891
15	Mason, Benj., Burnopfield, R.S.O., Durham	April 11, 1891
16	Nicholson, J. H., Seaton Delaval Colliery, Northumberland ...	Oct. 1, 1881
17	Oates, Robert J. W., Manager Rajdoha Mining Co., Limited, *via* Kalkapur, P.O., Dhalbhoin, District Singhbhoom, Bengal, India	Feb. 10, 1883
18	Parkinson, Wm., 5, Elm Street, South Moor, Chester-le-Street...	June 13, 1891
19	Richardson, Robert, Throckley Colliery, Newcastle-on-Tyne ...	Feb. 8, 1890
20	Riddell, John, Shilbottle Colliery, Lesbury, R.S.O., Northumberland	Dec. 14, 1889
21	Ridley, Geo. D., Tudhoe Colliery, Spennymoor	Feb. 8, 1890
22	Rontree, Thomas, Harton Colliery, South Shields	Aug. 2, 1890
23	Shaw, John, Cramlington Colliery, Northumberland	April 11, 1891
24	Southern, John, Heworth Colliery, Newcastle-on-Tyne	Dec. 14, 1889
25	Steavenson, C. H., Brotton Mines, Brotton, R.S.O., Yorkshire...	April 14, 1883
26	Stephenson, William, Garesfield Colliery, Lintz Green	Dec. 13, 1890
27	Walton, Matthew, Dearham Colliery, Carlisle	Dec. 14, 1889
28	Watson, Andrew, New Seaham Colliery, Sunderland	Feb. 8, 1890

Students.

		Elected.
1	Andrews, Geo. Murray, B.A., Broomhill Coll., Northumberland	Oct. 11, 1890
2	Bell, Walter, 23, Windsor Crescent, Newcastle	Oct. 12, 1889
3	Bitzos, N. J., Broomhill Colliery, Acklington	Feb. 14, 1891
4	Brown, Westgarth F., Alston House, Cardiff	Oct. 9, 1886
5	Burn, Frank H., Beaconsfield, Cullercoats	Feb. 9, 1889
6	Carr, John Evelyn, Cowpen Colliery, Blyth, Northumberland ...	June 8, 1889
7	Cochrane, Napier, Aldin Grange, Durham...	Dec. 8, 1888
8	Cole, Colin, De Beers Mine, Kimberley, South Africa	Oct. 18, 1882
9	Crawford, James Mill, Murton Colliery, near Sunderland ...	Dec. 11, 1882
10	Forster, George W., Heworth Colliery, near Newcastle-on-Tyne	Oct. 8, 1887
11	Gallwey, A. P., c/o Ed. Chester, Esq., Box 138, Post Office, Johannesburg, Z.A.R.	Oct. 2, 1880
12	Haggie, Douglas, Thorncliffe Iron Works, Sheffield	April 14, 1883
13	Hall, Fred. W., Durham Road, Leadgate, Co. Durham ...	June 8, 1888
14	Hare, Samuel, Brymbo Collieries, near Wrexham, North Wales	Aug. 2, 1879
15	Hay, William, Jun., Woodview House, Stanton, Burton-on-Trent	Dec. 10, 1883
16	Hurst, George, 58, Eldon Street, Newcastle-upon-Tyne... ...	April 14, 1883
17	Hutt, E. H., Holdfast Main Reef Gold Mining Company, Limited, Boksburg, Z. A. R.	Aug. 4, 1883
18	Kellett, Matthew H., Castle Eden Colliery, near Castle Eden	April 11, 1891
19	McMurtrie, G. E. J., Foxes Bridge Coll., Cinderford, Gloucestershire	Aug. 2, 1884
20	Mordy, Wm., Kimblesworth Colliery, Chester-le-Street... ...	April 11, 1891
21	Nicholson, A. D., Elemore Colliery, Fence Houses, Co. Durham	June 13, 1885
22	Patterson, Thomas, Craghead, Chester-le-Street...	April 13, 1889
23	Potter, E. A., Cramlington, Northumberland	Feb. 6, 1875
24	Pringle, Hy. Geo., Tanfield Lea Colliery, Lintz Green Station, Newcastle	Dec. 4, 1880
25	Redmayne, R. A. S., Manager, Walmsley Collieries, Limited, near Newcastle, Natal, South Africa	Dec. 13, 1884
26	Ridley, Wm., South Tanfield Colliery, Stanley, R.S.O., Newcastle-on-Tyne...	Dec. 11, 1882
27	Ritson, Jno. Ridley, High Marley Hill, Whickham, R.S.O. ...	April 11, 1891
28	Scott, Joseph S., East Hetton Colliery, Coxhoe, Co. Durham ...	Nov. 19, 1881
29	Shute, Wm. Ashley, Portland House, Eastbourne, Darlington	April 11, 1885
30	Stanton, Philip, Trimdon Grange, Co. Durham	Dec. 8, 1888
31	Sykes, Frank K., Springwell Villa, Bishop Auckland	Feb. 13, 1886
32	Waugh, C. L., Ffalda Steam Coal Coll., Garw Valley, nr. Bridgend	Nov. 19, 1881
33	Weightman, Percy O., Sheffield Road, Woodhouse, near Sheffield	Oct. 12, 1889
34	Wood, John, Coxhoe Hall, Coxhoe, R.S.O., Co. Durham ...	June 8, 1889
35	Yeoman, Thomas, Brandon Colliery, Co. Durham	Feb. 14, 1885
36	Zumbuloglon, Geo. Chrisostom, Broomhill Colliery, Acklington	Feb. 14, 1891

Subscribers under Bye-law 19.

1 Owners of Ashington Colliery, Newcastle-upon-Tyne.

2 Birtley Iron Company, Birtley.

3 Bridgewater Trustees, c/o Clifford Smith, Esq., Bridgewater Offices, Walkden, Bolton-le-Moors, Lancashire.

4 Marquess of Bute.

5 Earl of Durham, Lambton Offices, Fence Houses.

6 Haswell Coal Company, Haswell Colliery, Haswell, *via* Sunderland.

7 Hetton Coal Company, Fence Houses.

8 Hutton Henry Coal Company, Limited, 7, Bondgate, Darlington.

9 Marquess of Londonderry, c/o V. W. Corbett, Esq., Londonderry Offices, Seaham Harbour.

10 North Brancepeth Coal Company, Limited, 7, Bondgate, Darlington.

11 Owners of North Hetton Colliery, Fence Houses.

12 Ryhope Coal Company, Sunderland.

13 Owners of Seghill Colliery, Seghill, Northumberland.

14 Owners of South Hetton and Murton Collieries, 50, John Street, Sunderland.

15 Owners of Stella Colliery, Hedgefield, Blaydon-on-Tyne.

16 Owners of Throckley Colliery, Newcastle-upon-Tyne.

17 Owners of Victoria Garesfield Colliery, c/o George Peile, Esq., Shotley Bridge, co. Durham.

18 Owners of Wearmouth Colliery, Sunderland.

CHARTER

OF

THE NORTH OF ENGLAND

Institute of Mining and Mechanical Engineers.

FOUNDED 1852.

INCORPORATED NOVEMBER 28TH, 1876.

Victoria, by the Grace of God, of the United Kingdom of Great Britain and Ireland, Queen, Defender of the Faith, TO ALL TO WHOM THESE PRESENTS SHALL COME, GREETING :

WHEREAS it has been represented to us that NICHOLAS WOOD, of Hetton, in the County of Durham, Esquire (since deceased) ; THOMAS EMERSON FORSTER, of Newcastle-upon-Tyne, Esquire (since deceased) ; Sir GEORGE ELLIOT, Baronet (then George Elliot, Esquire), of Houghton Hall, in the said County of Durham, and EDWARD FENWICK BOYD, of Moor House, in the said County of Durham, Esquire, and others of our loving subjects, did, in the year one thousand eight hundred and fifty two, form themselves into a Society, which is known by the name of THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS, having for its objects the Prevention of Accidents in Mines and the advancement of the Sciences of Mining and Engineering generally, of which Society LINDSAY WOOD, of Southill, Chester-le-Street, in the County of Durham, Esquire, is the present President. AND WHEREAS it has been further represented to us that the Society was not constituted for gain, and that neither its projectors nor Members derive nor have derived pecuniary profit from its prosperity ; that it has during its existence of a period of nearly a quarter of a century steadily devoted itself to the preservation of human life and the safer development of mineral property ; that it has contributed substantially and beneficially to the prosperity of the country and the welfare and happiness of the working members of the community ; that the Society has since its establishment diligently pursued its aforesaid

objects, and in so doing has made costly experiments and researches with a view to the saving of life by improvements in the ventilation of mines, by ascertaining the conditions under which the safety lamp may be relied on for security; that the experiments conducted by the Society have related to accidents in mines of every description, and have not been limited to those proceeding from explosions; that the various modes of getting coal, whether by mechanical appliances or otherwise, have received careful and continuous attention, while the improvements in the mode of working and hauling belowground, the machinery employed for preventing the disastrous falls of roof underground, and the prevention of spontaneous combustion in seams of coal as well as in cargoes, and the providing additional security for the miners in ascending and descending the pits, the improvements in the cages used for this purpose, and in the safeguards against what is technically known as "overwinding," have been most successful in lessening the dangers of mining, and in preserving human life; that the Society has held meetings at stated periods, at which the results of the said experiments and researches have been considered and discussed, and has published a series of Transactions filling many volumes, and forming in itself a highly valuable Library of scientific reference, by which the same have been made known to the public, and has formed a Library of Scientific Works and Collections of Models and Apparatus, and that distinguished persons in foreign countries have availed themselves of the facilities afforded by the Society for communicating important scientific and practical discoveries, and thus a useful interchange of valuable information has been effected; that in particular, with regard to ventilation, the experiments and researches of the Society, which have involved much pecuniary outlay and personal labour, and the details of which are recorded in the successive volumes of the Society's Transactions, have led to large and important advances in the practical knowledge of that subject, and that the Society's researches have tended largely to increase the security of life; that the Members of the Society exceed 800 in number, and include a large proportion of the leading Mining Engineers in the United Kingdom. AND WHEREAS in order to secure the property of the Society, and to extend its useful operations, and to give it a more permanent establishment among the Scientific Institutions of Our Kingdom, We have been besought to grant to the said LINDSAY WOOD, and other the present Members of the Society, and to those who shall hereafter become Members thereof, our Royal Charter of Incorporation. NOW KNOW YE that We, being desirous of encouraging a design so laudable and salutary, of our especial grace, certain know-

ledge, and mere motion, have willed, granted, and declared, and do, by these presents, for us, our heirs, and successors, will, grant, and declare, that the said LINDSAY WOOD, and such others of our loving subjects as are now Members of the said Society, and such others as shall from time to time hereafter become Members thereof, according to such Bye-laws as shall be made as hereinafter mentioned, and their successors, shall for ever hereafter be, by virtue of these presents, one body, politic and corporate, by the name of "THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS," and by the name aforesaid shall have perpetual succession and a Common Seal, with full power and authority to alter, vary, break, and renew the same at their discretion, and by the same name to sue and be sued, implead and be impleaded, answer and be answered unto, in every Court of Us, Our heirs and successors, and be for ever able and capable in the law to purchase, acquire, receive, possess, hold, and enjoy to them and their successors any goods and chattels whatsoever, and also be able and capable in the law (notwithstanding the Statutes of Mortmain) to purchase, acquire, possess, hold and enjoy to them and their successors a hall or house, and any such other lands, tenements, or hereditaments whatsoever, as they may deem requisite for the purposes of the Society, the yearly value of which, including the site of the said hall or house, shall not exceed in the whole the sum of three thousand pounds, computing the same respectively at the rack rent which might have been had or gotten for the same respectively at the time of the purchase or acquisition thereof. AND WE DO HEREBY GRANT our especial license and authority unto all and every person and persons and bodies politic and corporate, otherwise competent, to grant, sell, alien, convey or devise in mortmain unto and to the use of the said Society and their successors, any lands, tenements, or hereditaments, not exceeding with the lands, tenements or hereditaments so purchased or previously acquired such annual value as aforesaid, and also any moneys, stocks, securities, and other personal estate to be laid out and disposed of in the purchase of any lands, tenements, or hereditaments not exceeding the like annual value. AND WE FURTHER will, grant, and declare, that the said Society shall have full power and authority, from time to time, to sell, grant, demise, exchange and dispose of absolutely, or by way of mortgage, or otherwise, any of the lands, tenements, hereditaments and possessions, wherein they have any estate or interest, or which they shall acquire as aforesaid, but that no sale, mortgage, or other disposition of any lands, tenements, or hereditaments of the Society shall be made, except with the approbation and concurrence of a General Meeting. AND Our will and

pleasure is, and we further grant and declare that for the better rule and government of the Society, and the direction and management of the concerns thereof, there shall be a Council of the Society, to be appointed from among the Members thereof, and to include the President and the Vice-Presidents, and such other office-bearers or past office-bearers as may be directed by such Bye-laws as hereinafter mentioned, but so that the Council, including all *ex-officio* Members thereof, shall consist of not more than forty or less than twelve Members, and that the Vice-Presidents shall be not more than six or less than two in number. AND WE DO HEREBY FURTHER will and declare that the said LINDSAY WOOD, shall be the first President of the Society, and the persons now being the Vice-Presidents, and the Treasurer and Secretary, shall be the first Vice-Presidents, and the first Treasurer and Secretary, and the persons now being the Members of the Council shall be the first Members of the Council of the Society, and that they respectively shall continue such until the first election shall be made at a General Meeting in pursuance of these presents. AND WE DO HEREBY FURTHER will and declare that, subject to the powers by these presents vested in the General Meetings of the Society, the Council shall have the management of the Society, and of the income and property thereof, including the appointment of officers and servants, the definition of their duties, and the removal of any of such officers and servants, and generally may do all such acts and deeds as they shall deem necessary or fitting to be done, in order to carry into full operation and effect the objects and purposes of the Society, but so always that the same be not inconsistent with, or repugnant to, any of the provisions of this our Charter, or the Laws of our Realm, or any Bye-law of the Society in force for the time being. AND WE DO FURTHER will and declare that at any General Meeting of the Society, it shall be lawful for the Society, subject as hereinafter mentioned, to make such Bye-laws as to them shall seem necessary or proper for the regulation and good government of the Society, and of the Members and affairs thereof, and generally for carrying the objects of the Society into full and complete effect, and particularly (and without its being intended hereby to prejudice the foregoing generality), to make Bye-laws for all or any of the purposes hereinafter mentioned, that is to say: for fixing the number of Vice-Presidents, and the number of Members of which the Council shall consist, and the manner of electing the President and Vice-Presidents, and other Members of the Council, and the period of their continuance in office, and the manner and time of supplying any vacancy therein; and for regulating the times at which General Meetings of the Society and Meetings of the Council shall be held,

and for convening the same and regulating the proceedings thereat, and for regulating the manner of admitting persons to be Members of the Society, and of removing or expelling Members from the Society, and for imposing reasonable fines or penalties for non-performance of any such Bye-laws, or for disobedience thereto, and from time to time to annul, alter, or change any such Bye-laws so always that all Bye-laws to be made as aforesaid be not repugnant to these presents, or to any of the laws of our Realm. AND WE DO FURTHER will and declare that the present Rules and Regulations of the Society, so far as they are not inconsistent with these presents, shall continue in force, and be deemed the Bye-laws of the Society until the same shall be altered by a General Meeting, PROVIDED ALWAYS that the present Rules and Regulations of the Society and any future Bye-laws of the Society so to be made as aforesaid shall have no force or effect whatsoever until the same shall have been approved in writing by our Secretary of State for the Home Department. IN WITNESS WHEREOF WE HAVE CAUSED THESE OUR LETTERS TO BE MADE PATENT.

WITNESS Ourself at Our Palace, at Westminster, this 28th day of November, in the fortieth year of Our Reign.

BY HER MAJESTY'S COMMAND,

CARDEW.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

BYE-LAWS

PASSED AT A SPECIAL GENERAL MEETING HELD ON THE 8TH OF JUNE, 1889.

I.—CONSTITUTION.

1.—The North of England Institute of Mining and Mechanical Engineers shall consist of Members, Associate Members, and Honorary Members. The Institute shall in addition comprise Associates and Students.

2.—The Officers of the Institute, other than the Treasurer and the Secretary, shall be elected from the Members and Associate Members, and shall consist of a President, six Vice-Presidents, and eighteen Councillors, who, with the Treasurer and the Secretary (if Members of the Institute) shall constitute the Council.

All Past-Presidents shall be *ex-officio* Members of the Council, so long as they continue Members or Associate Members of the Institute; and Vice-Presidents who have not been re-elected or have become ineligible from having held office for three consecutive years, shall be *ex-officio* Members of the Council for the following year.

II.—QUALIFICATIONS OF MEMBERS, ASSOCIATE MEMBERS, HONORARY MEMBERS, ASSOCIATES, AND STUDENTS.

3.—MEMBERS.—Every candidate for admission into the class of Members, or for transfer into that class, shall come within the following conditions:—He shall be more than twenty-three years of age, have been regularly educated as a Mining or Mechanical Engineer, or in some other branch of Engineering, according to the usual routine of pupilage, and have had subsequent employment for at least two years in some responsible situation as an Engineer, or if he has not undergone the usual routine of pupilage, he must have been employed or have practised as an Engineer for at least five years. This class shall also comprise every person who was an Ordinary Member, Life Member, or Student on the first of August, 1877.

4.—ASSOCIATE MEMBERS shall be persons connected with or interested in Mining or Engineering, and not practising as Mining or Mechanical Engineers, or in some other branch of Engineering.

5.—HONORARY MEMBERS shall be persons who have distinguished themselves by their literary or scientific attainments, or who have made important communications to the Society.

6.—ASSOCIATES shall be persons acting as under-viewers, under-managers, or in other subordinate positions in mines, or employed in analogous positions in other branches of Engineering.

7.—STUDENTS shall be persons who are qualifying themselves for the profession of Mining or Mechanical Engineering, or other branch of Engineering, and such persons may continue Students until they attain the age of twenty-five years.

III.—ELECTION AND EXPULSION OF MEMBERS.

8.—Any person desirous of becoming a Member, an Associate Member, an Associate, or a Student, shall be proposed according to the Forms A, B, C, or D respectively in the Appendix, in which Form the name, usual residence, and qualifications of the candidate shall be distinctly specified The Form must be signed by the proposer and at least two other Member, or Associate Members, certifying a personal knowledge of the candidate.

Any person qualified to become an Honorary Member shall be proposed according to the Form E in the Appendix, in which Form the names usual residence, and qualifications of the candidate shall be distinctly stated. This Form must be signed by the proposer and at least five other Members or Associate Members, certifying a personal knowledge of the candidate, and the Council shall have the power of defining the time during which, and the circumstances under which the candidate shall be an Honorary Member.

Any Associate or Student desirous of becoming a Member, shall be proposed and recommended according to the Form F in the Appendix, in which Form the name, usual residence, and qualifications of the candidate shall be distinctly specified. This Form must be signed by the proposer and at least two other Members, or Associate Members, certifying a personal knowledge of the candidate, and the proposal shall then be treated in the manner hereinafter described.

Every proposal shall be delivered to the Secretary, and by him submitted to the next meeting of the Council, who, on approving the qualifications, shall determine if the candidate is to be presented for ballot, and if it is so determined, the Chairman of the Council shall sign

such proposal. The same shall be read at the next Ordinary General Meeting, and afterwards be exhibited in the Institute's Hall until the following Ordinary General Meeting, when the candidate shall be balloted for.

A Student may become an Associate at any time after attaining the age of twenty-one years.

9.—The balloting shall be conducted in the following manner:—Each Member or Associate Member attending the meeting at which a ballot is to take place, shall be supplied (on demand) with a list of the names of the persons to be balloted for, according to the Form G in the Appendix, and shall strike out the names of such candidates as he desires shall not be elected, and return the list to the scrutineers appointed by the presiding Chairman for the purpose, and such scrutineers shall examine the lists so returned, and inform the meeting what elections have been made. No candidate shall be elected unless he secures the votes of two-thirds of the Members and Associate Members voting.

10.—Notice of election shall be sent to every person within one week after his election, according to the Form H in the Appendix, enclosing at the same time a copy of Form I, which shall be returned by the person elected, signed, and accompanied with the amount of his annual subscription, or life composition, within two months from the date of such election, which otherwise shall become void.

11.—Every Member having signed a declaration in the Form I, and having likewise made the proper payment, shall receive a certificate of his election, according to the Form J.

12.—Any Member, Associate Member, Associate, or Student elected at any meeting between the Annual Meetings shall be entitled to all Transactions issued in the Institute's year, so soon as he has signed and returned Form I, and paid his subscription.

13.—The Transactions of the Institute shall not be forwarded to those whose subscriptions are in arrear on the 1st of May in each year.

14.—Any person whose subscription is more than one year in arrear shall be reported to the Council, who shall direct application to be made for it, according to the Form K in the Appendix, and in the event of its continuing one month in arrear after such application, the Council shall have the power, after remonstrance by letter to his last recorded address in the books of the Society, according to the Form L in the Appendix, of declaring that the defaulter has ceased to be a Member.

15.—In case the expulsion of any person shall be judged expedient by ten or more Members, or Associate Members, and they think fit to

draw up and sign a proposal requiring such expulsion, the same being delivered to the Secretary, shall be by him laid before the next meeting of the Council for consideration. If the Council, after due inquiry, do not find reason to concur in the proposal, no entry thereof shall be made in any minutes, nor shall any public discussion thereon be permitted, unless by requisition signed by one-half of the Members or Associate Members of the Institute; but if the Council do find good reason for the proposed expulsion, they shall direct the Secretary to address a letter, according to the Form M in the Appendix, to the person proposed to be expelled, advising him to withdraw from the Institute. If that advice be followed, no entry on the minutes nor any public discussion on the subject shall be permitted; but if that advice be not followed, nor an explanation given which is satisfactory to the Council, they shall call a General Meeting for the purpose of deciding on the question of expulsion; and if a majority of the Members and Associate Members present at such meeting (provided the number so present be not less than forty) vote that such person be expelled, the Chairman of that meeting shall declare the same accordingly, and the Secretary shall communicate the same to the person, according to the Form N in the Appendix.

IV.—Subscriptions.

16.—The annual subscription of each Member and Associate Member shall be £2 2s., of each Associate and Student £1 1s., payable in advance, and shall be considered due on election, and afterwards on the first Saturday in August of each year.

17.—Any Member or Associate Member may, at any time, compound for all future subscriptions by a payment of £25, or on such other conditions as the Council may, in writing, accept. Every person so compounding shall be a Member or an Associate Member for life, as the case may be. Any Associate Member so compounding who may afterwards be qualified to become a Member, may do so, by election, in the manner described in Bye-law 8.

18.—In case any Member, Associate Member, or Associate who has been long distinguished in his professional career, becomes unable, from ill-health, advanced age, or other sufficient cause, to carry on a lucrative practice, the Council may, on the report of a Sub-Committee appointed by them for that purpose, if they find good reason for the remission of the annual subscription, so remit it. They may also remit any arrears which are due from a Member, or they may accept from him a collection of books, or drawings, or models, or other contributions, in lieu of the

composition mentioned in Bye-law 17, and may thereupon release him from any or all future subscriptions, and permit him to resume his former rank in the Institute.

19.—Owners of Collieries, Engineers, Manufacturers, Railway Companies, and Employers of labour generally, may subscribe annually to the funds of the Institute, and each such subscriber of £2 2s. annually shall be entitled to tickets to admit two persons to the rooms, library, meetings, lectures, and public proceedings of the Society; and for every additional £2 2s., subscribed annually, two other persons shall be admissible; and each such subscriber shall also be entitled for each £2 2s. subscription to have a copy of the Transactions of the Institute sent to him.

V.—Election of Officers.

20.—The President, Vice-Presidents, and Councillors shall be elected at the Annual Meeting in August (except in cases of vacancies) and shall be eligible for re-election to any office, with the exception of any President who may have held office for the two immediately preceding years, or Vice-President who may have held office for the three immediately preceding years, and such six Councillors as may have attended the fewest Council Meetings during the past year, and when any such attendances are equal, the Council shall decide between them; but any such Member or Associate Member shall be eligible for re-election after being one year out of office.

Any Retiring Vice-President or Councillor who may be ineligible for re-election shall nevertheless be eligible to any other office.

21.—Each Member, and Associate Member, shall be at liberty to nominate in writing, and send to the Secretary not less than eight days prior to the Ordinary General Meeting in June, a list, duly signed, of Members and Associate Members suitable to fill the offices of President, Vice-Presidents, and Members of Council, for the ensuing year. The Council shall prepare a list of the persons so nominated, together with the names of the Officers for the current year eligible for re-election, and of such other Members and Associate Members as they deem suitable for the various offices. Such list shall comprise the names of not less than thirty persons. The list so prepared by the Council shall be submitted to the General Meeting in June, and shall be the balloting list for the annual election in August. (See Form O in the Appendix.) A copy of this list shall be posted at least seven days previous to the Annual Meeting, to every Member and Associate Member, who may erase any name or names from the list, and substitute the name or names of any other

Member or Associate Member eligible for each respective office; but the number of names on the list, after such erasure or substitution, must not exceed the number to be elected to the respective offices. Papers which do not accord with these directions shall be rejected by the scrutineers. The votes for any Member who may not be elected President or Vice-Presidents shall count for them as Members of the Council, but in no case shall he receive more than one vote from each voter. The Chairman shall appoint four scrutineers, who shall receive the balloting papers, and, after making the necessary scrutiny, destroy the same, and sign and hand to the Chairman a list of the elected Officers. The balloting papers may be returned through the post, addressed to the Secretary, or be handed to him, or to the Chairman of the meeting, so as to be received before the appointment of the scrutineers for the election of Officers.

22.—In case of the decease, expulsion, or resignation of any Officer or Officers, the Council, if they deem it requisite that the vacancy shall be filled up, shall present to the next Ordinary General Meeting a list of persons whom they nominate as suitable for the vacant office or offices, and a new Officer or Officers shall be elected at the first succeeding Ordinary General Meeting.

23.—The Treasurer and the Secretary shall be appointed by the Council, and shall be removable by the Council, subject to appeal to a General Meeting. One and the same person may hold both these offices.

VI.—Duties of the Officers and Council.

24.—The President shall take the chair at all meetings of the Institute, the Council, and Committees, at which he is present (he being *ex-officio* a member of all), and shall regulate and keep order in the proceedings.

25.—In the absence of the President, it shall be the duty of the senior Vice-President present to preside at the meetings of the Institute, to keep order, and to regulate the proceedings. In case of the absence of the President and of all the Vice-Presidents, the meeting may elect any Member of Council, or in case of their absence, any Member or Associate Member present, to take the chair at the meeting.

26.—At meetings of the Council, five shall be a quorum. The minutes of the Council's proceedings shall be at all times open to the inspection of the Members and Associate Members.

27.—The Treasurer and the Secretary shall act under the direction and control of the Council, by which body their duties shall from time to time be defined.

28.—The Council may appoint Committees for the purpose of transacting any particular business, or of investigating any specific subject connected with the objects of the Institute. Such Committees shall make a report to the Council, who shall act thereon, and make use thereof as they see occasion.

VII.—Communications and Memoirs.

29.—All papers shall be sent for the approval of the Council at least twenty-one days before a General Meeting, and after approval, shall be read before the Institute. The Council shall also direct whether any paper read before the Institute shall be printed in the Transactions, and immediate notice shall be given to the writer whether it is to be printed or not.

30.—The copyright of all papers communicated to, and accepted for printing by the Council, and printed within twelve months, shall become vested in the Institute, and such communications shall not be published for sale or otherwise, without the written permission of the Council.

31.—Twenty copies of each paper printed by the Institute shall be presented to the author for private use.

32.—All proofs of reports of discussions, forwarded to any person for correction, must be returned to the Secretary within seven days from the date of their receipt, otherwise they will be considered correct and be printed off.

33.—The Institute is not, as a body, responsible for the statements and opinions advanced in the papers which may be read, nor in the discussions which may take place at the meetings of the Institute.

VIII.—Meetings of the Institute.

34.—An Ordinary General Meeting shall be held on the first Saturday of every month (except January and July) at two o'clock, unless otherwise determined by the Council; and the Ordinary General Meeting in the month of August shall be the Annual Meeting, at which a report of the proceedings, and an abstract of the accounts of the previous year, shall be presented by the Council.

35.—All donations to the Institute shall be acknowledged in the Annual Report of the Council.

36.—A Special General Meeting shall be called whenever the Council may think fit, and also on a requisition to the Council, signed by ten or more Members or Associate Members. The business of a Special Meeting shall be confined to that specified in the notice convening it.

37.—The Members, Associate Members, Honorary Members, Associates and Students, shall have notice of, and the privilege to attend, all Ordinary General Meetings and Special Meetings.

38.—Every question, not otherwise provided for, which shall come before any meeting, shall be decided by the votes of the majority of the Members and Associate Members then present.

39.—Invitations shall be forwarded to any person whose presence at the discussions the Council may think advisable, and strangers so invited shall be permitted to take part in the proceedings but not to vote.

Any Member or Associate Member shall have power to introduce two strangers (see Form P) to any General Meeting, but they shall not take part in the proceedings except by permission of the meeting.

IX.—Property of the Institute.

40.—The Funds of the Society shall be deposited in the hands of the Treasurer, and shall be disbursed or invested by him according to the direction of the Council.

41.—The Institute Hall and Reading Room shall be open to the Members, Associate Members, Honorary Members, Associates and Students on every week day, from 10 a.m. to 5 p.m., except on such special day or days when the Council shall think it expedient to close the rooms and suspend the circulation of Books. Books shall be issued according to regulations from time to time approved by the Council.

42.—No duplicate copies of any portion of the Transactions shall be issued to any Member, Associate Member, Associate or Student, unless by order from the Council.

X.—Alteration of Bye-laws.

43.—No alteration shall be made in the Bye-laws of the Institute, except at the Annual Meeting, or at a Special Meeting for that purpose, and the particulars of every such alteration shall be announced at a previous Ordinary Meeting, and inserted in its minutes, and shall be exhibited in the room of the Institute fourteen days previous to such Annual or Special Meeting, and such Meeting shall have power to adopt any modification of such proposed alteration of the Bye-laws.

I hereby approve the foregoing Bye-laws,

HENRY MATTHEWS,

One of Her Majesty's Principal Secretaries of State.

Whitehall,
29th June, 1891.

APPENDIX TO THE BYE-LAWS.

[FORM A.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being upwards of twenty-three years of age, and desirous of becoming a Member of the North of England Institute of Mining and Mechanical Engineers, I recommend him, from *personal knowledge*, as a person in every respect worthy of that distinction, because—

[*Here specify distinctly the qualifications of the Candidate, according to the spirit of Bye-law 3.*]

On the above grounds, I propose him to the Council as a proper person to be admitted a Member.

Signed.....Member or Associate Member.

Dated this..... ...day of .....18 .

We, the undersigned, concur in the above recommendation, being convinced that A. B. is in every respect a proper person to be admitted a Member.

FROM PERSONAL KNOWLEDGE.

..... } Two Members
..... } or Associate Members.

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as a Member of the North of England Institute of Mining and Mechanical Engineers.

Signed .....Chairman.

Dated this.....day of.....18 .

[FORM B.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being desirous of becoming an Associate Member of the North of England Institute of Mining and Mechanical Engineers, I recommend him, from *personal knowledge*, as a person in every respect worthy of that distinction, and propose him to the Council as a proper person to be admitted an Associate Member.

Signed.....Member or Associate Member.

Dated this..... day of.. .....18 .

We, the undersigned, concur in the above recommendation, being convinced that A. B. is in every respect a proper person to be admitted an Associate Member.

FROM PERSONAL KNOWLEDGE.

..... } Two Members
..... } or Associate Members.

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as an Associate Member of the North of England Institute of Mining and Mechanical Engineers.

Signed..... .....Chairman.

Dated this.....day of.....18 .

[FORM C.]

A B. [Christian Name, Surname, Occupation, and Address in full], being desirous of becoming an Associate of the North of England Institute of Mining and Mechanical Engineers, I recommend him, from *personal knowledge*, as a person in every respect worthy of that distinction, and propose him to the Council as a proper person to be admitted as an Associate.

Signed .....Member or Associate Member.

Dated this.....day of.....18 .

We, the undersigned, concur in the above recommendation, being convinced that A. B. is in every respect a proper person to be admitted as an Associate.

FROM PERSONAL KNOWLEDGE.

..... } Two Members
..... } or Associate Members.

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as an Associate of the North of England Institute of Mining and Mechanical Engineers.

Signed.....Chairman.

Dated this.....day of..... .....18 .

[FORM D.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being under twenty-five years of age and desirous of becoming a Student of the North of England Institute of Mining and Mechanical Engineers, I recommend him, from *personal knowledge*, as a person in every respect worthy of that distinction, and propose him to the Council as a proper person to be admitted as a Student.

Signed..... .....Member or Associate Member.

Dated this.....day of.....18 .

We, the undersigned, concur in the above recommendation, being convinced that A. B. is in every respect a proper person to be admitted a Student.

FROM PERSONAL KNOWLEDGE.

.... } Two Members
..... } or Associate Members.

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as a Student of the North of England Institute of Mining and Mechanical Engineers.

Signed.....Chairman.

Dated this.....day of.....18

[FORM E.]

I recommend A. B. [Christian Name, Surname, Occupation, and Address in full], from *personal knowledge*, as a person in every respect qualified to become an Honorary Member of the North of England Institute of Mining and Mechanical Engineers, because—

[*Here specify distinctly the qualifications of the Candidate, according to the spirit of Bye-law 5.*]

On the above grounds, I propose him to the Council as a proper person to be admitted an Honorary Member.

Signed.....Member or Associate Member.

Dated this.....day of.....18

We, the undersigned, concur in the above recommendation, being convinced that A. B. is in every respect a proper person to be admitted an Honorary Member.

FROM PERSONAL KNOWLEDGE.

.....
.....
..... } Five Members or Associate Members.
.....
.....

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as an Honorary Member of the North of England Institute of Mining and Mechanical Engineers.

Signed.....Chairman.

Dated this.....day of.....18

[FORM F.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being at present a.....of the North of England Institute of Mining and Mechanical Engineers, and upwards of twenty-three years of age, and being desirous of becoming a Member of the said Institute, I recommend him, from *personal knowledge*, as a person in every respect worthy of that distinction, because—

[*Here specify distinctly the qualifications of the Candidate, according to the spirit of Bye-law 3.*]

On the above grounds, I propose him to the Council as a proper person to be admitted a Member.

Signed.....Member or Associate Member.

Dated this.....day of.....18 .

We, the undersigned, concur in the above recommendation, being convinced that A. B. is in every respect a proper person to be admitted a Member.

FROM PERSONAL KNOWLEDGE.

..... } Two Members
..... } or Associate Members.

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as a Member of the North of England Institute of Mining and Mechanical Engineers.

Signed.....Chairman.

Dated this..... .....day of.....18 .

[FORM G.]

List of the names of persons to be balloted for at the General Meeting on..... .... , the .....day of.....18 .

MEMBERS :—

.....

.....

ASSOCIATE MEMBERS :—

.....

.....

HONORARY MEMBERS :—

.....

.....

ASSOCIATES :—

.....

.....

STUDENTS :—

... .

....

Strike out the names of such persons as you desire should *not* be elected, and hand the list to the Chairman.

[FORM H.]

SIR,—I beg leave to inform you that on the.....day of..... you were elected a... .....of the North of England Institute of Mining and Mechanical Engineers. In conformity with its Rules your election cannot be confirmed until the enclosed form be returned to me with your signature, and until your first annual subscription be paid, the amount of which is £....., or, at your option the life-composition of £25.

If the subscription is not received within two months from the present date, the election will become void under Bye-law 10.

I am, sir, yours faithfully,

.....Secretary.

Dated.....18 .

[FORM I.]

I, the undersigned, being elected a..... .....of the North of England Institute of Mining and Mechanical Engineers, do hereby agree that I will be governed by the Charter and Bye-laws of the said Institute for the time being; and that I will advance the objects of the Institute as far as shall be in my power, and will not aid in any unauthorised publication of the proceedings, and will attend the meetings thereof as often as I conveniently can; provided that whenever I shall signify in writing to the Secretary that I am desirous of withdrawing my name therefrom, I shall (after the payment of any arrears which may be due by me at that period) cease to be a Member.

Witness my hand this.....day of..... .....18 .

[FORM J.]

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

Founded 1852. Incorporated by Royal Charter, A.D., 1876.

These are to certify that A. B. [Christian Name, Surname, Occupation, and Address in full] was elected a Member of the North of England Institute of Mining and Mechanical Engineers, at a General Meeting held on the. ... .day of .....18 .

Witness our hands and Seal this .....day of.....18 .

SEAL.

....President.

....Secretary.

[FORM K.]

SIR,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to draw your attention to Bye-law 14, and to remind you that the sum of £.....of your annual subscriptions to the funds of the Institute remains unpaid, and that you are in consequence in arrear of subscription. I am also directed to request that you will cause the same to be paid without further delay, otherwise the Council will be under the necessity of exercising their discretion as to using the power vested in them by the Article above referred to.

I am, sir, yours faithfully,

.....Secretary.

Dated.....18 .

[FORM L.]

SIR,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to inform you, that in consequence of non-payment of your arrears of subscription, and in pursuance of Bye-law 14, the Council have determined that unless payment of the amount £.....is made previous to the.....day of..... .....next, they will proceed to declare that you have ceased to be a Member of the Institute.

But, notwithstanding this declaration, you will remain liable for payment of the arrears due from you.

I am, sir, yours faithfully,

.....Secretary.

Dated..... ... .18 .

[FORM M.]

SIR,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to inform you that, upon mature consideration of a proposal which has been laid before them relative to you, they feel it their duty to advise you to withdraw from the Institute, or otherwise they will be obliged to act in accordance with Bye-law 15.

I am, sir, yours faithfully,

.....Secretary.

Dated.....18 .

[FORM N.]

SIR,—It is my duty to inform you that, under a resolution passed at a Special General Meeting of the North of England Institute of Mining and Mechanical Engineers, held on the.....day of.....18 ....., according to the provisions of Bye-law 15, you have ceased to be a.....of the Institute.

I am, sir, yours faithfully,

.....Secretary.

Dated..... 18

[FORM O.]

BALLOTING LIST,.....

Ballot to take place at the Annual Meeting on.....18.....at Two o'clock, p.m.

The names of persons for whom the voter does *not* vote must be erased, and the names of other persons eligible for re-election may be inserted in their place, provided the number remaining on the list does not exceed the number of persons to be elected.

PRESIDENT—Not more than ONE NAME to be returned, or the vote will be lost.

_____ President for the current year eligible for re-election.*

_____ } New Nominations.*

VICE-PRESIDENTS—Not more than SIX NAMES to be returned, or the vote will be lost.

The Votes for any Member who may not be elected President or Vice-Presidents shall count for them as Members of the Council, but in no case shall he receive more than one vote from each voter.

_____ } Vice-Presidents for the current year eligible for re-election.

_____ } New Nominations.

COUNCIL—Not more than EIGHTEEN NAMES to be returned, or the vote will be lost.

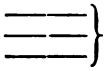
_____ } Members of the Council for the current year eligible for re-election.

_____ } New Nominations.

Any list returned with a greater number of Names than ONE PRESIDENT, SIX VICE-PRESIDENTS, or EIGHTEEN COUNCILLORS, Will be rejected by the Scrutineers as informal, and the Votes will consequently be lost.

* To be inserted when necessary.

EX-OFFICIO MEMBERS of the Council for the ensuing year :—



Extract from Bye law 21.

Each Member, and Associate Member, shall be at liberty to nominate in writing, and send to the Secretary not less than eight days prior to the Ordinary General Meeting in June, a list, duly signed, of Members and Associate Members suitable to fill the offices of President, Vice-Presidents, and Members of Council, for the ensuing year. The Council shall prepare a list of the persons so nominated, together with the names of the Officers for the current year eligible for re-election, and of such other Members and Associate Members as they deem suitable for the various offices. Such list shall comprise the names of not less than thirty persons. The list so prepared by the Council shall be submitted to the General Meeting in June, and shall be the balloting list for the annual election in August. [See Form O in the Appendix.] A copy of this list shall be posted at least seven days previous to the Annual Meeting, to every Member and Associate Member, who may erase any name or names from the list, and substitute the name or names of any other Member or Associate Member eligible for each respective office; but the number of names on the list, after such erasure or substitution must not exceed the number to be elected to the respective offices. Papers which do not accord with these directions shall be rejected by the scrutineers. The votes for any Member who may not be elected President or Vice-Presidents shall count for them as Members of the Council, but in no case shall he receive more than one vote from each voter. The Chairman shall appoint four scrutineers, who shall receive the balloting papers, and, after making the necessary scrutiny, destroy the same, and sign and hand to the Chairman a list of the elected Officers. The balloting papers may be returned through the post, addressed to the Secretary, or be handed to him, or to the Chairman of the meeting, so as to be received before the appointment of the scrutineers for the election of Officers.

Names substituted for any of the above are to be written in the blank spaces opposite those they are intended to supersede.

The following Members are ineligible from causes specified in Bye-law 20 :—

AS PRESIDENT.....

AS VICE-PRESIDENT.....

AS COUNCILLORS.....

[FORM P.]

Admit.....

of.....

to the General Meeting on Saturday, the.....

(Signature of Member, Associate Member, Associate, or Student).....

The Chair to be taken at Two o'Clock p.m.

I undertake to abide by the Regulations of the North of England Institute of Mining and Mechanical Engineers, and not to aid in any unauthorised publication of the Proceedings.

(Signature of Visitor).....

Not transferable.

FEDERATED INSTITUTION OF MINING ENGINEERS.

FOUNDED JULY 1ST, 1889.

Bye-Laws passed at Council Meeting held on the 28th of May, 1891.

I.—CONSTITUTION.

1.—The Federated Institution of Mining Engineers shall consist of all or any of the societies interested in the advancement of mining, metallurgy, engineering, and their allied industries, who shall from time to time join together and adhere to the Bye-Laws.

2.—The Institution shall have for its objects—

(*a*) The advancement and encouragement of the sciences of mining, metallurgy engineering, and their allied industries.

(*b*) The interchange of opinions, by the reading of communications from members and others, and by discussions at general meetings, upon improvements in mining, metallurgy, engineering, and their allied industries.

(*c*) The publication of original communications, discussions, and other papers connected with the objects of the Institution.

(*d*) The purchase and disposal of real and personal property for such objects.

(*e*) The performance of all things connected with or leading to the purpose of such objects.

3.—The offices of the Institution shall be in Newcastle-upon-Tyne, or such other place as shall be from time to time determined by resolution of the Council.

4.—The year of the Institution shall end on July 31st in every year.

5.—The affairs and business of the Institution shall be managed and controlled by the Council.

II.—MEMBERSHIP.

6.—The original adherents or founders are as follow:—

(*a*) Chesterfield and Midland Counties Institution of Engineers, Chesterfield.

(*b*) Midland Institute of Mining, Civil, and Mechanical Engineers, Barnsley.

(*c*) North of England Institute of Mining and Mechanical Engineers, Newcastle-upon-Tyne.

(*d*) South Staffordshire and East Worcestershire Institute of Mining Engineers, Birmingham.

7.—Written applications from societies to enter the Institution shall be made to the Council, by the President of the applying society, who shall furnish any information that may be desired by the Council.

8.—A.—If desired by the Council, any of the Federated Institutes shall revise their Bye-Laws, in order that their members shall consist of Ordinary Members, Associate Members, and Honorary Members, with Associates and Students, and section B following shall be a model Bye-Law to be adopted by any society when so desired by the Council.

B.—"The members shall consist of Ordinary Members, Associate Members, and Honorary Members, with Associates and Students:—

(*a*) Each Ordinary Member shall be more than twenty-three years of age, have been regularly educated as a mining, metallurgical or mechanical engineer, or in some other branch of engineering according to the usual routine of pupilage, and have had subsequent employment for at least two years in some responsible situation as an engineer; or if he has not undergone the usual routine of pupilage, he must have been employed or have practised as an engineer for at least five years.

(*b*) Each Associate Member shall be a person connected with or interested in mining, metallurgy, or engineering, and not practising as a mining, metallurgical, or mechanical engineer, or some other branch of engineering.

(*c*) Each Honorary Member shall be a person who has distinguished himself by his literary or scientific attainments, or who may have made important communications to any of the Federated Institutes.

(*d*) Associates shall be persons acting as under-viewers, under-managers, or in other subordinate positions in mines or metallurgical works, or employed in analogous positions in other branches of engineering.

(*e*) Students shall be persons who are qualifying themselves for the profession of mining, metallurgical, or mechanical engineering, or other branch of engineering, and such persons may continue Students until they attain the age of twenty-five years."

9.—The Ordinary Members, Associate Members, and Honorary Members, Associates and Students shall have notice of and the privilege of attending the ordinary and annual general meetings, and shall receive all publications of the Institution. They may also have access to, and take part in, the general meetings of any of the Federated Institutes.

10.—The members of any Federated Institute, whose payments to the Institution are in arrear, shall not receive the publications and other privileges of the Institution.

11.—After explanations have been asked by the President from any Federated Institute, whose payments are in arrear, and have not been paid within one month after written application by the Secretary, the Council may decide upon its suspension or expulsion from the Institution; but such suspension or expulsion shall only be decided at a meeting attended by at least two-thirds of the members of the Council by a majority of three-fourths of the members present.

III.—Subscriptions.

12.—Each of the Federated Institutes shall pay fifteen shillings per annum for each Ordinary Member, Associate Member, Honorary Member, Associate, and Student, or such other sum, and in such instalment or instalments as may be determined from time to time by resolution or resolutions of the Council. Persons joining any of the Federated Institutes during the financial year of the Federated Institution shall be entitled to all publications issued for that year, after his election is notified to the Secretary, and the instalment or instalments due on his behalf have been paid.

IV.—Election of Officers and Council.

13.—The officers of the Institution, other than the Secretary and Treasurer, shall consist of Councillors elected annually prior to August in each year, by and out of the Ordinary Members and Associate Members of each Federated Institute, in the proportion of one Councillor per forty Ordinary Members or Associate Members thereof; of Vice-Presidents elected by and from the Council at their first meeting in each year on behalf of each Institute, in the proportion of one Vice-President per two hundred Ordinary Members or Associate Members thereof; and of a President elected by and from the Council at their first meeting in each year; who, with the Local Secretaries of each Federated Institute and the Secretary and Treasurer, shall form the Council. All Presidents on retiring from that office shall be *ex-officio* Vice-Presidents so long as they continue Ordinary Members or Associate Members of any of the Federated Institutes.

14.—In case of the decease, expulsion, or resignation of any officer or officers, the Council may, if they deem it requisite, fill up the vacant office or offices at their next meeting.

V.—Duties of Officers and Council.

15.—The Council shall represent the Institution and shall act in its name, and shall make such calls upon the Federated Institutes as they may deem necessary, and shall transact all business and examine accounts, authorise payments, and may invest or use the funds in such manner as they may from time to time think fit, in accordance with the objects and Bye-Laws of the Institution.

16.—The Council shall decide the question of the admission of any society, and may decree the suspension or expulsion of any Federated Institute for non-payment of subscriptions.

17.—The Council shall decide upon the publication of any co mmunications.

18.—There shall be three ordinary meetings of the Council in each year, on the same day as, but prior to, the ordinary or annual general meetings of the members.

19.—A special meeting of the Council shall be called whenever the President may think fit, or upon a requisition to the Secretary signed by ten or more of its members, or by the President of any of the Federated Institutes. The business transacted at a special meeting of the Council shall be confined to that spectfied in the notice convening it.

20.—The meetings of the Council shall be called by circular letter, issued to all the members at least seven days previously, accompanied by an agenda paper, stating the nature of the business to be transacted.

21.—The order in which business shall be taken at the ordinary and annual general meetings may be, from time to time, decided by the Council.

22.—The Council may communicate with the Government in cases of contemplated or existing legislation, of a character affecting the interests of mining, metallurgy, engineering, or their allied industries.

23.—The Council may appoint Committees, consisting of members of the Institution, for the purpose of transacting any particular business, or of investigating any specific subject connected with the objects of the Institution.

24.—A Committee shall not have power or control over the funds of the Institution, beyond the amount voted for its use by the Council.

25.—Committees shall report to the Council, who shall act thereon and make use thereof as they may elect.

26.—The President shall take the chair at all meetings of the Institution, the Council, and Committees at which he may be present.

27.—In the absence of the President, it shall be the duty of the senior Vice-President present to preside at the meetings of the Institution. In case of the absence of the President and of all the Vice-Presidents, the meeting may elect any member of Council, or in case of their absence any Ordinary Member or Associate Member to take the chair at the meeting.

28.—At meetings of the Council six shall be a quorum.

29.—Every question shall be decided at the meetings of the Council by the votes of the majority of the members present. In case of equal voting, the President, or other member presiding in his absence, shall have a casting vote. Upon the request of two members, the vote upon any question shall be by ballot.

30.—The Secretary shall be appointed by and shall act under the direction and control of the Council. The duties and salary of the Secretary shall be fixed and varied from time to time at the will of the Council.

31.—The Secretary shall summon and attend all meetings of the Council, and the ordinary and annual general meetings of the Institution, and shall record the proceedings in the minute book. He shall direct the administrative and scientific publications of the Institution. He shall have charge of and conduct all correspondence relative to the business and proceedings of the Institution, and of all committees where necessary, and shall prepare and issue all circulars to the members.

32.—One and the same person may hold the office of Secretary and Treasurer.

33.—The Treasurer shall be appointed annually by the Council at their first meeting in each year. The income of the Institution shall be received by him, and shall be paid into Messrs. Lambton and Co.'s bank at Newcastle-upon-Tyne, or such other bank as may be determined from time to time by the Council.

34.—The Treasurer shall make all payments on behalf of the Institution, by cheques signed by two members of Council, the Treasurer, and the Secretary, after payments have been sanctioned by Council.

35.—The surplus funds may, after resolution of the Council, be invested in Government securities, in railway and other debenture shares such as are allowed for investment by trustees, in the purchase of land, or in the purchase, erection, alteration, or furnishing of buildings for the use of the Institution. All investments shall be made in the names of Trustees appointed by the Council.

36.—The accounts of the Treasurer and the financial statement of the Council shall be audited and examined by a chartered accountant, appointed by the Council at their first meeting in each year. The accountants' charges shall be paid out of the funds of the Institution.

37.—The minutes of the Council's proceedings shall at all times be open to the inspection of the Ordinary Members and Associate Members.

VI.—General Meetings.

38.—An ordinary general meeting shall be held in February, May, and September, unless otherwise determined by the Council; and the ordinary general meeting in the month of September shall be the annual general meeting at which a report of the proceedings, and an abstract of the accounts of the previous year ending July 31st, shall be presented by the Council. The ordinary general meeting in the month of May shall be held in London, at which the President may deliver an address.

39.—Invitations may be sent by the Secretary to any person whose presence at discussions shall be thought desirable by the Council, and persons so invited shall be permitted to read papers and take part in the proceedings and discussions.

40.—Discussion may be invited on any paper published by the Institution, at meetings of any of the Federated Institutes, at which the writer of the paper may be invited to attend. Such discussion, however, shall in all cases be submitted to the writer of the paper before publication, and he may append a reply at the end of the discussion.

VII.—Publications.

41.—The publications may comprise—

(*a*) Papers upon the working of mines, metallurgy, engineering, railways, and the various allied industries.

(*b*) Papers on the management of industrial operations.

(*c*) Abstracts of foreign papers upon similar subjects.

(*d*) An abstract of the patents relating to mining and metallurgy, etc.

(*e*) Notes of questions of law concerning mines, manufactures, railways, etc.

42.—Each paper (with complete drawings, if any, to scale), to be read at any meeting of the Institution or of any of the Federated Institutes shall be placed in the hands of the Secretary at least fourteen days before the date of the meeting at which the paper is to be read, and shall, subject to the approval of the Council, be printed, together with any discussion or remarks thereon.

43.—The Council may accept communications from persons who are not members of the Institution and allow them to be read at the ordinary or annual general meetings.

44.—No paper which has already been published (except as provided for in Bye-Law 41), shall appear in the publications of the Institution.

45.—A paper in course of publication cannot be withdrawn by the writer.

46.—Proofs of all papers and reports of discussions forwarded to any person for revision must be returned to the Secretary within seven days from the date of their receipt, otherwise they will be considered correct and be printed off.

47.—The copyright of all papers accepted for printing by the Council shall become vested in the Institution, and such communications shall not be published for sale or otherwise without the written permission of the Council.

48.—Twenty copies of each paper and the accompanying discussion shall be presented to the writer free of cost. He may also obtain additional copies upon payment of the cost to the Secretary, by an application attached to his paper. These copies must be unaltered copies of the paper as appearing in the publication of the Institution, and the cover shall state that it is an "Excerpt from the Transactions of the Federated Institution of Mining Engineers."

49.—The Federated Institutes may receive copies of their own portion of the publications in respect of such of their members as do not become members of the Federated Institution, and shall pay 10s. per annum in respect of every copy so supplied; and similar copies for exchanges shall be paid for at cost price.

50.—The Local Secretary of each Federated Institute shall prepare and edit all papers and discussions of such Institute, and promptly forward them to the Secretary, who shall submit proofs to the Local Secretary before publication.

51.—A list of the members, with their last known addresses, shall be printed in the publications of the Institution.

52.—The publications of the Institution shall only be supplied to members, and no duplicate copies of any portion of the publications shall be issued to any member or Federated Institute unless by order of the Council.

53.—The annual volume or volumes of the publications may be sold, in the complete form only, at such prices as may be determined from time to time by the Council; to non-members for not less than £3; and to members who are desirous of completing their sets of the publications, for not less than 15s.

54.—The Institution as a body is not responsible for the statements and opinions advanced in the papers which may be read or in the discussions which may take place at the meetings of the Institution, or of the Federated Institutes.

VIII.—Medals and other Rewards.

55.—The Council may award annually the sum of twenty pounds, in the form of medals or other rewards, to the authors of papers published by the Institution.

IX.—Property.

56.—The capital fund shall consist of such amounts as shall from time to time be determined by resolution of the Council.

57.—The Institution may make use of the following receipts for its expenses :—

(*a*) The interest of its accumulated capital fund;

(*b*) The annual subscriptions; and

(*c*) Receipts of all other descriptions.

58.—The Institution may form a collection of papers, books, and models.

59.—Societies or members who may have ceased their connection with the Institution shall have no claim to participate in any of its properties.

60.—All donations to the Institution shall be acknowledged in the annual report of the Council.

X.—Alteration of Bye-Laws.

61.—No alteration shall be made in the Bye-Laws of the Institution, except at a special meeting of the Council called for that purpose, and the particulars of every such alteration shall be announced at their previous meeting, and inserted in the minutes, and shall be sent to all members of Council at least fourteen days previous to such special meeting, and such special meeting shall have power to adopt any modification of such proposed alteration of the Bye-Laws, subject to confirmation by the next ensuing Council meeting.

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